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Relationship between cervical lateral flexion and stingers in collegiate football

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RELATIONSHIP BETWEEN CERVICAL LATERAL FLEXION AND STINGERS IN COLLEGIATE FOOTBALL

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ABSTRACT

THE RELATIONSHIP BETWEEN CERVICAL LATERAL FLEXION AND THE OCCURRENCE OF STINGERS IN COLLEGIATE FOOTBALL PLAYERS

by Jeffrey A. Sullivan

This study examined the relationship between cervical lateral flexion range of motion and the occurrence of stingers in collegiate football players (N = 92) during a single season. The influences of previous stinger injury, player position, year in school, and cervical girth on stinger occurrence were investigated to identify injury patterns.

To determine if limited range of motion made players susceptible to stingers, lateral flexion was measured using the CROM® Inclinometer and compared between injured and uninjured players. Previous stinger injury, lateral flexion, player position, and year in school were each assessed to determine potential predictors of stingers. No evidence was found that limited lateral flexion made players susceptible to stingers. History of previous stinger injury was a statistically significant predictor of the occurrence of stingers.

Obtaining the student-athlete's history of injury is important in stinger prevention. A preseason screening which assesses history, cervical range of motion, player position, cervical girth, and year in school may aid sports medicine personnel in identifying athletes susceptible to stingers.

Dedicated to my dad

David M. Sullivan

who would have been proud.

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INTRODUCTION

The stinger injury is a common occurrence in collegiate football. As many as 70% of collegiate football players have experienced a stinger while playing. The injury has been reported in as many as 52% of players during a single season (Sallis, Jones, & Knopp, 1992). A stinger has been repeatedly described in the literature as a transient nerve injury to the brachial plexus, usually lasting less than five minutes. Many coaches and athletes fail to report stingers to their sports medicine staff because the symptoms are typically resolved within minutes (O'Conner, Pekow, & Klingensmith, 1996). As a result, stingers may be grossly underreported in collegiate football.

Sallis et al. (1992) reported that 87% of the players experiencing a stinger had recurrent stinger episodes. Prolonged damage and irrecoverable nerve function have been shown with repeated stinger episodes, even though research indicates that the risk of permanent nerve damage is small (Clancy, Brand, & Bergfield, 1977; Robertson, Eichman & Clancy, 1979; Speer & Bassett, 1990). The National Collegiate Athletic Association (NCAA) has no clear guidelines regarding management of recurrent stingers and return to competition (NCAA Sports Medicine Handbook, 1999).

Student-athletes who experience a stinger or recurrent stingers should report each injury to their athletic trainer or team physician; however, approximately 70% of players who experience stingers admit they have not reported all stingers to their athletic trainers or other sports medicine staff (Speer & Bassett, 1990). Since symptoms are transient and rarely result in actual time loss from games or practice, stingers do not meet the requirement for reporting in the NCAA Injury Surveillance System (O'Conner et al., 1996).

Thus, the occurrence reported in the literature has been both imprecise and inconsistent. The actual number of stinger injuries occurring in college football remains obscure.

Certain risk factors may increase a player's likelihood of having a stinger including: position played, level of play, neck type (skinny and long, or thick and short), neck strength, cervical range of motion, history of stingers, and other factors (Albright, McAuley, Martin, Crowley, & Foster, 1985; Vereschagin, Weins, Fanton, & Dillingham, 1991). Players who have long, skinny, inflexible necks should be identified and undergo neck and shoulder strengthening exercises during the preseason to prevent possible stinger injuries (Vereschagin et al., 1991).

Limited cervical range of motion is one potential risk factor for stingers. Studies have shown that lateral flexion may be limited after a stinger injury (Chrisman, Snook, Stanitis, & Keedy, 1965); however, limited lateral flexion has yet to be determined as a predisposing factor to a stinger. The present study obtained cervical lateral flexion range of motion measurements taken during preseason physicals. Also, a collegiate football team was prospectively followed to document the occurrence of stingers throughout a football season. Injured subjects had their preseason range of motion values compared to uninjured subjects to determine if injured subjects demonstrated limited lateral flexion.

The NCAA recommends that a stinger assessment be part of the student-athlete's preseason physical examination so that players at risk can be identified (NCAA, 1999). The rationale for the recommendation is that individuals could then be instructed in a preventive strengthening program and given proper protective equipment in order to reduce stinger injuries. This study proposes that, in addition to these precautions, cervical mobility should be addressed and range of motion exercises should be implemented in order to aid in preventing stingers.

Identification of new stinger risk factors may allow sports medicine personnel to decrease the number of these injuries in collegiate football. Implementing preventive and rehabilitative programs, including range of motion exercises, will contribute to stinger prevention strategies.

Statement of the Problem

Nearly 70% of collegiate football players will experience a stinger during their career; and up to 87% of these players will have recurrent stingers (Sallis et al., 1992). Many stingers go unreported by athletes. Previous studies involving stingers have focused subject examination on strength and sensation testing, conducting electrodiagnostic studies, obtaining radiographs, and determining history of injury (Albright et al., 1985; Bergfield, Hershman, & Wilbourne, 1988; Levitz, Reilly, & Torg, 1993; Robertson et al., 1979; Sallis et al., 1992; Speer & Bassett, 1990). No study has examined cervical range of motion before a stinger occurs. Markey, DiBenedetto, and Curl (1993) performed measurements on subjects after they reported symptoms of a stinger. Albright et al. (1985) did so to determine if a physical examination was normal or abnormal.

Stingers may cause a limitation of lateral flexion toward the affected side (Chrisman et al., 1965); however, the relationship of limited cervical lateral flexion to the subsequent occurrence of stingers has not been evaluated.

Purpose of the Study

The purpose of this study was to examine the relationship between cervical lateral flexion range of motion and the occurrence of stingers in collegiate football players during a single football season. Demographic information was gathered to identify patterns and risk factors associated with the stinger injury.

Hypotheses

The following hypotheses were made for the purpose of the study:

1. Injured subjects will exhibit limited preseason cervical lateral flexion range of motion values when compared with uninjured subjects. The lateral flexion dysfunction may be on the ipsilateral or contralateral side of the stinger injury.

2. Football athletes at high risk for stingers may be identified by limited cervical lateral flexion range of motion, previous history of injury, year in school, and position played.

Delimitations

This study was delimited to male Division one collegiate football players at Stanford University. Active cervical range of motion measurements were taken only in the coronal (frontal) plane. Measurements were delimited to the seated position only.

Limitations

Generalization of the results were limited because the subjects were all highly-skilled Division 1 football players, close in age (17-25), and on the same collegiate football team.

Performance on range of motion measurements was based on subject motivation. Reporting on the preseason questionnaire was limited by the subject's honesty in describing his medical history of stingers. The questionnaire relied on the subject's recollection of injury. Reporting of stinger injury was limited by the athlete's willingness to present their symptoms to a staff athletic trainer. Also, certain subjects may have demonstrated diminished cervical lateral flexion range of motion due to previous stinger injury. This represented a threat to internal validity.

Definitions of Terms

Catastrophic Head or Neck Injury. A fatal or seriously disabling sports-related injury to the head or cervical spine (i.e. cervical fracture, permanent cervical quadriplegia, or intracranial hemorrhage) (Torg, Vegso, Sennett, & Das, 1985).

Certified Athletic Trainer (ATC). An allied health professional who works under the direction of a supervising physician and provides services, including injury prevention, evaluation, immediate care, treatment, and rehabilitation of injuries and illnesses in physically active individuals (Rankin & Ingersoll, 1995). The Certified Athletic Trainer has successfully completed a certification examination administered by the National Athletic Trainers Association Board of Certification (NATABOC).

Lateral Flexion. The bending of the spinal column in the coronal plane around the anterior/posterior axis (Hay & Reid, 1988).

Lesion. A change in tissue structure due to injury or disease (Sedon, 1972).

Noncatastrophic Head or Neck Injury. A head or neck injury which does not lead to death or permanent paralysis (i.e. transient brachial plexopathy) (Albright, Van Gilder, El-Khoury, Crowley, & Foster, 1984).

Neurapraxia. The mildest form of brachial plexus injury (including stingers) in which full recovery from symptoms occurs within minutes to days (Sallis et al., 1992).

Range of Motion (ROM). "The angle through which a joint moves from the anatomical position to the extreme limit of segment motion in a particular anatomical position to the extreme limit of segment motion in a particular direction" (Hall, 1991, p.134).

Transient Brachial Plexopathy. A temporary dysfunction of either the brachial plexus or a cervical nerve root caused by a blow to either the head, neck, or shoulder (Sallis et al., 1992).

One operational definition was used throughout this study:

Stinger/Stinger Syndrome: an injury caused by a blow to the head, neck, or shoulder resulting in sudden burning pain, numbness, tingling, and/or weakness of the injured side which may extend from the neck, to the shoulder, down the arm, and/or into the hand and fingers. Symptoms may resolve after a short period of time (5-10 minutes), or may last for extended periods of time (months to years).

Summary

Stingers are a common occurrence in collegiate football. Reported occurrence in the literature has been imprecise, ranging from 50-70% of those playing football. O'Conner et al. (1996) reported that up to 70% of players who experience the injury do not report it to their athletic training staff. Recurrent stingers present a management challenge to sports medicine personnel. Permanent nerve damage is a potential problem with repeated stingers. Several risk factors have been identified which may increase an athlete's chances of having a stinger. Limited cervical lateral flexion has not been researched as a potential risk factor.

Previous studies have focused their attention on physical examination involving manual muscle testing, sensory testing, radiography, electromyography, and other tests. No known study has measured pre-participation and pre-injury cervical range of motion. Cervical range of motion participation and pre-injury cervical range of motion. Cervical range of motion has been shown to be limited on the affected side after a stinger injury (Chrisman et al.,1965); however, limited cervical lateral flexion has not been studied as a predictor of subsequent stingers. The intent of this research was to examine the relationship between cervical lateral flexion and the occurrence of stingers in the collegiate football setting. Demographic information was also analyzed to identify risk factors and injury patterns associated with stingers.

Chapter II

REVIEW OF LITERATURE

Introduction

Injuries to the head and neck in participants of American football have been evident since the beginning of the sport. The occurrence of severe head and neck injury, such as permanent cervical quadriplegia, concussion, and even death was significant enough in 1904 to warrant national attention from President Theodore Roosevelt, who insisted on an end to the "brutality" involved in football, or that the game be abandoned entirely. Roosevelt's concerns led to the establishment of the National Collegiate Athletic Association (NCAA) (Albright, McAuley, et al., 1985). In 1975, the NCAA, along with the National Federation of High School Athletic Associations (NFHSAA) established rules outlawing the intentional use of the helmet and face mask in tackling and blocking. These rules resulted from research by Torg, Truex, Quedenfeld, and Burstein from 1971-1975. These authors used cinematography and epidemiologic data to reveal that the majority of cervical spine injuries were caused by axial loading to the vertebrae (Torg, Truex, Quedenfeld, & Burstein, 1979). On the basis of these observations, and because of a concern that headgear was being used as a weapon when tackling, rules were initiated banning intentional "spearing" and the illegal use of the top of the helmet for initial contact. The implementation of these rules, beginning in 1976, has been associated with a significant reduction in severe head and neck injuries (Torg, 1985). In 1977 and 1980, further rule changes were developed which allowed offensive lineman to use their hands and arms more freely to block opponents. As a result, Albright et al. (1985), during an 8-year prospective study, noted a dramatic reduction in the occurrence of head and neck injury. The legislative rule changes were cited as influential factors in this reduction. Overall, the occurrence of permanent cervical quadriplegia decreased from 34 in 1976 to 5 in 1984 (Torg et al., 1985). These statistics describing catastrophic injury are encouraging; however, they do not represent the more frequently occurring noncatastrophic injury.

The Stinger Injury

The stinger injury is a noncatastophic injury which occurs more frequently in contact sports than catastrophic injuries such as permanent quadriplegia. Recent studies reveal that stingers occur more commonly in contact sports than previously reported (Vereschagin, Wiens, Fanton, & Dillingham, 1991).

The stinger has been described in the literature as a temporary dysfunction of either the brachial plexus or a cervical nerve root after a blow to the head, neck or shoulder (Albright et al., 1984; Chrisman et al., 1965; Clancy et al., 1977; Levitz et al., 1993; Markey et al., 1993; Poindexter & Johnson, 1984; Sallis et al., 1992; Speer & Bassett, 1990).

This injury has been referred to in the literature as "the stinger syndrome", "brachial plexopathy", "transient brachial plexopathy", and "nerve root", "brachial plexus", or "cervical nerve pinch neurapraxia." Common euphemisms used by athletes, coaches, and others include "pinched nerve", "stinger", "burner", "dead arm", "zinger", or "hot shot" (Chrisman et al., 1965; Clancy et al., 1977; Maroon, Steele, & Berlin, 1980; Robertson et al., 1979).

Although few studies have been performed on the stinger phenomenon, it has recently become a subject of increasing interest in the literature (Sallis et al., 1992). Stingers most commonly occur in contact sports, with football demonstrating the highest incidence of injury. Stingers have also been reported in basketball, ice hockey, wrestling, and some field events in track and field (Bateman, 1967; Chrisman et al., 1965).

Symptoms of Injury

Stingers ("burners") are so named because the injuries can exhibit a sudden burning sensation usually extending from the neck into the forearm and hand. Athletes who experience a stinger will typically present with their involved arm held close to their side and the inability to move the extremity. Injured players will commonly complain of burning pain, numbness, and tingling possibly traveling from the involved side of the neck into the shoulder. Symptoms may extend down the arm to the forearm and into the hand and fingers (NCAA, 1999). Muscular weakness may be evident, but is usually transient, lasting up to 10-15 minutes (Torg, Sennett, Pavlov, Leventhal, & Glasgow, 1993). The term neurapraxia was first used by Seddon (1972) to describe this condition of transient paresis (Clancy et al., 1977). Neurapraxia describes the mildest form of brachial plexus neuropathy in which symptoms usually subside within minutes to days (Sallis et al., 1992). Some studies have reported severe cases where symptoms have persisted. In extreme instances, muscular weakness may remain for several weeks to several months (Bateman, 1967).

The fifth and sixth cervical nerve roots (C5 & C6) are the most commonly affected roots, with sensory and motor disturbances exhibited along their distribution (see Figure 1) (Speer & Bassett, 1990; Vereschagin et al., 1991; Sallis et al., 1992; Clancy, 1979; Markey et al., 1993; Albright et al., 1984). One study found that residual muscle weakness occurred most often in the deltoid muscle (Bergfield et al., 1988). The injured athlete may also exhibit diminished deep-tendon reflexes at the fifth through seventh cervical nerve roots (C5-C7) (Vereschagin et al., 1991).

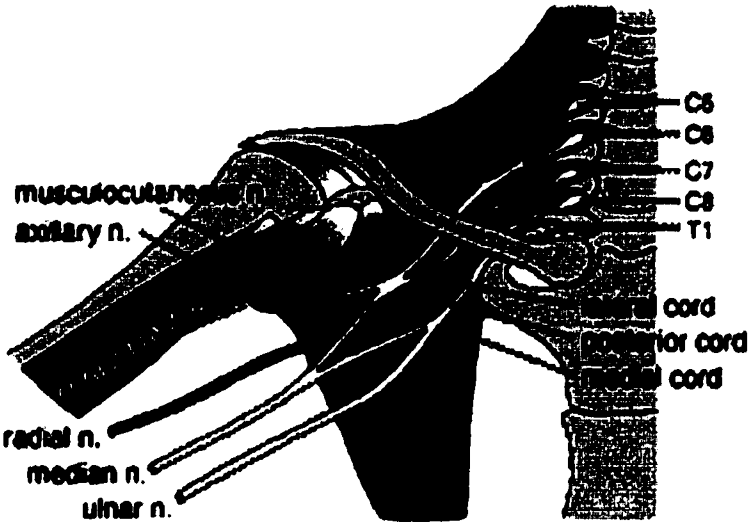

Figure 1. Anatomy of the Brachial Plexus.
From http://depts.washington.edu/anesth/regional/brachialplexusanatomy.html
Public Domain.

Mechanism of Injury

The literature presents three mechanisms causing the stinger injury: 1) traction of the brachial plexus, caused by forced lateral flexion of the neck with contralateral shoulder depression (see Figure 2A), 2) direct trauma to the brachial plexus at its most superficial aspect (see arrow in Figure 2B, "Erbs point"), (see Figure 2B), or 3) nerve root compression in the intervertebral foraminal space, caused by forced extension of the neck with ipsilateral compression (see Figure 2C), (Levitz et al., 1993). Hyperextension and hyperflexion of the neck, usually without cervical rotation, have also been reported in the literature (Albright et al., 1985; Bateman, 1967; Clancy et al., 1977; Robertson et al., 1979; O'Conner et al., 1996).

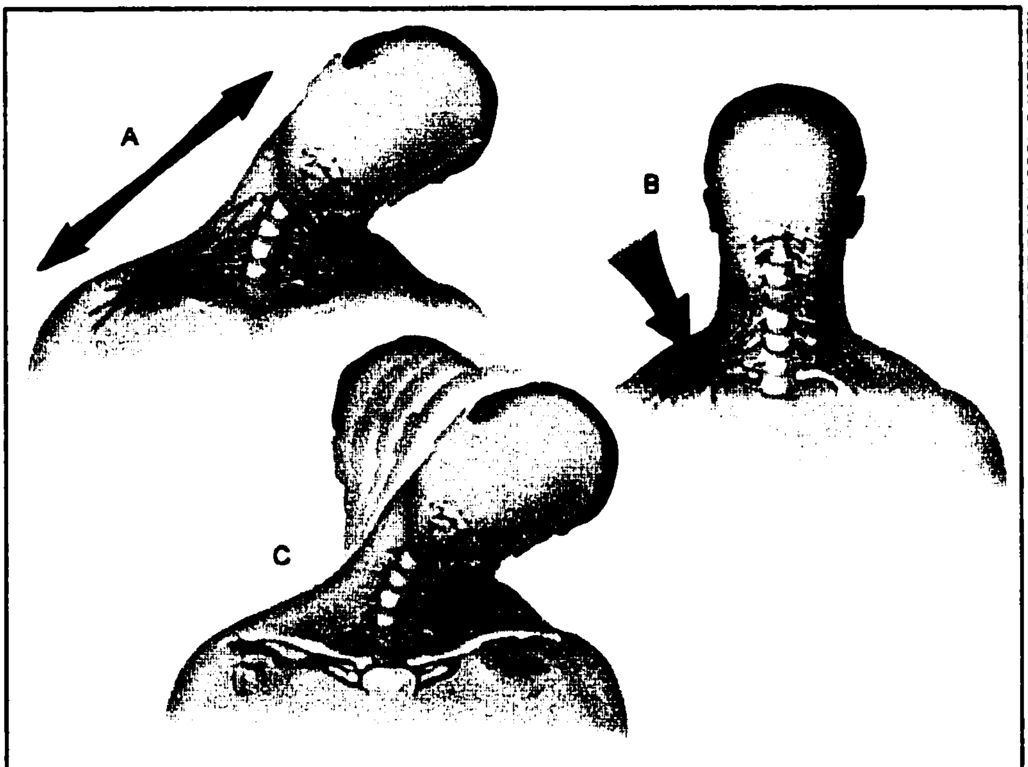

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Figure 2. Mechanisms of Stinger Injury: A) traction of the brachial plexus, B) direct trauma to the brachial plexus, and C) nerve root compression.

Researchers disagree on the most common mechanism of injury. More than 30 years ago, one study cited lateral flexion as the most common mechanism causing stingers (Chrisman et al., 1965). Chrisman stated that cervical nervous tissue was stretched simultaneously with the other soft tissue of the neck during forced lateral flexion. The study involved 22 athletes with a "nerve pinch" injury, 17 of whom were football players and 22 control athletes without the injury. Lateral flexion measurements were taken for each subject in both directions. The authors found that along with neurologic changes, consistent limitation of cervical lateral flexion toward the injured side was observed. For example, if an athlete received a blow on the right side and his neck was forced left, his symptoms would occur down the right extremity. The athlete later demonstrated an observable limitation in lateral flexion toward the right. Injured subjects were found to have an average difference in lateral flexion motion of 9.5° between the sides, compared with 1.9° for the controls. The difference was statistically significant ($p > 0.01$). The limitation in motion was attributed to a sprain of the lateral ligaments of the neck and a lower cervical nerve root stretch. The authors reasoned that swelling and fibrosis around the intervertebral foramen would then limit lateral flexion toward the injured side. Full range of motion was prevented due to nerve root compression and facet joint dysfunction. Evidence of limited lateral flexion was found in the subjects, with no evidence of limited cervical extension, rotation, or flexion (Chrisman et al., 1965).

More recently researchers have supported Chrisman et al. (1965), maintaining that stingers are typically the result of a lateral flexion mechanism causing traction to the brachial plexus (Clancy et al., 1977; Levitz et al., 1993; Sallis et al., 1992; Vereschagin et al., 1991). Robertson et al. (1979) further elucidated the pathomechanics by finding that the brachial plexus stretch occurs at Erb's point (see Figure 2B).

The stinger injury may also result from a nerve root compression mechanism. The nerve root becomes compressed between vertebra when the neck is forced into lateral flexion with rotation and extension toward one side (see Figure 2C). Poindexter and Johnson (1984) proposed that stingers more commonly occur from a nerve root compression mechanism than from traction to the brachial plexus. The authors performed EMG's on twelve football players. Eleven of the twelve players exhibited C6 nerve root radiculopathy (i.e. pain along the course of the nerve) rather than lateral stretch of the brachial plexus. Forced cervical hyperextension was the most common mechanism causing compression to the nerve root. Levitz et al. (1993) reported that nerve root compression in the intervertebral foramina resulting from disk degeneration was a more frequent cause of recurrent stingers in collegiate and professional football players. Levitz et al. proposed that further study may show nerve root compression to be the cause of initial stinger occurrence; however, a 10-year prospective study at the University of Iowa demonstrated that disk degeneration was unlikely to cause the stinger syndrome. Results demonstrated a less than 20% prevalence of disk disease in those experiencing stingers (Albright et al., 1984).

Markey et al. (1993) recently cited compression to the fixed brachial plexus as a third mechanism of stinger injury. Markey et al. demonstrated that compression of the brachial plexus between the shoulder pads and the superior medial scapula may cause the stinger syndrome. Five players were found to have shoulder pads forced up into the Erb's point area, where the brachial plexus is most superficial (see Figure 2B). Markey et al. designed a "total-contact neck-shoulder-chest orthosis" to protect the upper body of the football player from compressive forces while blocking and tackling. A neck roll was added to limit neck motion and to prevent the shoulder pads from being forced into the neck. A preliminary study found that the orthosis was effective in reducing the severity and recurrence of stingers in three of five athletes. The authors acknowledged that further prospective studies need to be done to validate the effectiveness of this type of orthosis (Markey et al., 1993). In addition to this orthosis, a variety of neck rolls and other devices exist which may limit neck motion, thus potentially reducing the incidence of stingers (see Figure 3).

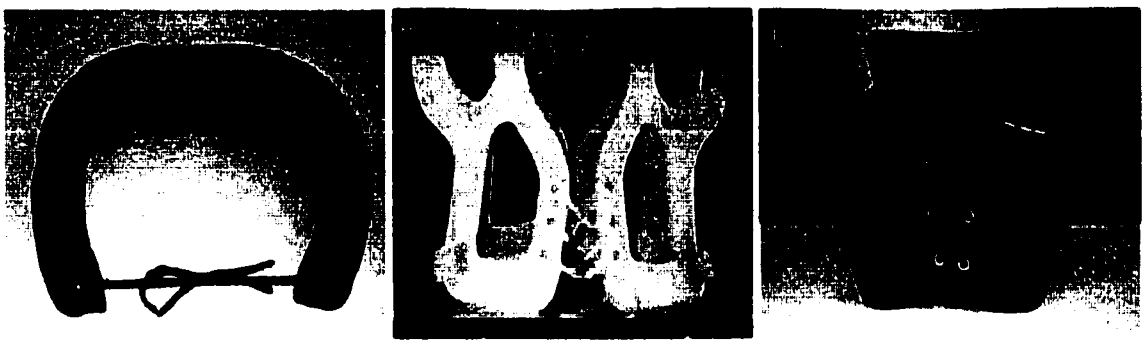


Figure 3. Examples of Protective Neck Equipment: A) a neck role which attaches to the shoulder pads, B) shock pads worn under the shoulder pads, and C) a cowboy collar worn under the shoulder pads.
From "The 'Burner': A Common Nerve Injury in Contact Sports," by G. S. Kuhlman and D. B. McKeag, 1999, American Family Physician, 60, p. 2039. Copyright by the American Academy of Family Physicians. Reprinted with permission. All Rights Reserved.

Determining exactly where the lesion occurs in the stinger injury is often very difficult. Literature varies on whether a stinger involves injury to the brachial plexus, more proximally to the nerve root, or both the plexus and nerve roots. Rockett (1982) proposed that a stinger involves injury primarily at the nerve root. He described the nerve root becoming scarred and adhering to surrounding structures (the scalene muscles and vertebral transverse processes) after being repeatedly stretched. Surgical intervention involving nerve root decompression offered relief of symptoms. Markey et al. (1993) stated that compression injuries to the neck may affect the brachial plexus and the nerve roots simultaneously.

Speer and Bassett (1990) explained that with traction injuries, the brachial plexus and nerve roots are tightened and affected together. Whether the traction force is greater on the upper or lower plexus, or whether it affects all parts, depends on the severity of the force and limb position.

Electromyographic (EMG) Findings

The clinical distinction between cervical radiculopathy, caused by compression of the nerve root, and brachial plexopathy, caused by traction or compression to the brachial plexus, presents a challenge. Differentiating between the two often requires electromyography (EMG) and nerve conduction velocity measurements (Robertson et al., 1979); however, few stinger studies have reported EMG findings. Robertson et al. used needle EMG to isolate the lesion to the upper trunk (C5-C6) of the brachial plexus. Their research has been validated by similar studies isolating the upper trunk of the plexus as being primarily involved (Clancy et al., 1977; Markey et al., 1993; Speer & Bassett, 1990.) The upper trunk of the brachial plexus seems to be the most vulnerable area for the stinger injury to occur. In athletes experiencing sensory and motor deficits, the deltoid, infraspinatus, supraspinatus and biceps brachii are the most frequently involved muscles (Clancy et al., 1977; Robertson et al., 1979; Sallis et al., 1992; Speer and Bassett, 1990.)

Bergfield et al. (1988) found that 80% of athletes with stingers exhibited abnormal EMG findings. Twenty athletes with the stinger syndrome were followed from 1 to 8 years after injury. Although their clinical examination had returned to normal, the athletes' EMG findings continued to be abnormal at follow-up evaluation, showing increased activity years after injury. Consequently, the authors suggested that the EMG findings were too sensitive in certain cases, and that clinical examination, rather than EMG findings, should be used for decisions regarding return to play.

The NCAA has established no clear guidelines with regards to return to play after stinger injury. Research suggests that many factors should be addressed in return to play decision-making including: the athlete's history of stinger injury, length of time that symptoms persisted, upper extremity muscular function, and sensory perception. The present study attempted to identify lateral flexion ROM as an additional factor which should be addressed before an athlete returns to play.

Incidence of Stingers

The reported incidence of stingers in football has been imprecise and inconsistent throughout the literature. Numerous authors have described the occurrence of stingers in high school, collegiate, and professional football settings (Albright et al., 1984; Castro, Ricciardi, Brunet, Busch, & Whitecloud, 1997; Chrisman et al., 1965; Clancy et al., 1977; Levitz et al., 1993; Markey et al., 1993; Marshall, 1970; O'Connor et al., 1996; Poindexter & Johnson, 1984; Sallis et al., 1992; Speer and Bassett, 1990; Vereschagin et al., 1991). Studies have yielded occurrences of 5% per year (Marshall, 1970), 20% of 200 West Point intramural players (DiBenedetto & Markey, 1984), and 50% of 67 varsity football players at the University of Wisconsin (Robertson et al., 1979).

Recent reports suggest that the occurrence of stingers may have previously been underreported. Sallis et al. (1992) surveyed 201 NCAA Division III football players. Sixty-five percent of those surveyed had experienced a stinger at some time during their college careers, 52% had experienced a stinger during the 1991 football season, and 57% experienced recurrent stingers. Eighty-seven percent of the players experiencing a stinger reported recurrent episodes. Stingers went unreported by 70% of the players experiencing them. Sallis et al. suggest that unreported stingers such as these may have contributed to the skewed occurrence of stingers found in previous literature. Sallis et al. assert that athletic trainers and physicians need to look more vigilantly for these injuries, both on the field and in the screening evaluation. The present study will closely monitor a single team during the football season to facilitate an accurate recording of stingers. Thus, the author will have a more precise incidence of stingers than previous studies.

Players with Increased Risk

The likelihood that a football player will experience a stinger either during his football career or during a particular season is difficult to predict. Factors that contribute to the occurrence of stingers are age, position played, level of play, on-field time, style of play, player size, player strength, and even genetic makeup may play a role (Vereschagin et al., 1991).

Defensive players have been shown to have an increased risk of injury compared with their offensive counterparts. Vereschagin et al. (1991) found that defensive players were more than two times as likely to sustain a stinger than their offensive counterparts (27 injuries vs. 11 injuries). Utilizing a preseason questionnaire, Marzo, Simmons, & Whieldon (1991) found that, among position players, linebackers and defensive backs were at greatest risk for injury. Stingers occurred more frequently while making tackles than while blocking or being tackled. Sallis et al. (1992) also cited defensive backs for the highest occurrence of stingers (30% of the reported stingers), followed by defensive and offensive linemen (18% and 17%, respectively).

A recent study conducted at Amhurst College analyzed risk factors and occurrence of brachial plexus nerve injuries in collegiate football players (O'Conner et al., 1996). A significant trend of increasing injury rate was cited, with freshman being injured the least, followed by sophomores, juniors, and seniors being the most likely injured. O'Connor et al. also found a strong association ($p < .001$) between previous injury and the likelihood of recurrent injury. Players experiencing a stinger in the previous season had four times the risk of injury as those with no previous history.

Cervical Range of Motion: Lateral Flexion

Forced lateral flexion of the neck, combined with contralateral shoulder depression, has been the most commonly reported mechanism of injury in a number of studies involving stingers (Chrisman et al., 1965; Clancy et al., 1977; Levitz et al., 1993; Sallis et al., 1992; Vereschagin et al., 1991).

Hay and Reid (1988) have defined lateral flexion as the bending of the spine toward one side or the other in the frontal plane. Lateral flexion, combined with flexion, extension, and rotation, gives the cervical spine the capacity for widely diversified motion. Although lateral flexion is a function of combined movements in all cervical vertebrae, it does not occur as an independent motion, but incorporates an element of cervical rotation (Hoppenfeld, 1976). Normal Active Range of Motion (AROM) and Passive Range of Motion (PROM) for lateral flexion is approximately 45° (Hoppenfeld, 1976); however, numerous studies have proposed norms for cervical range of motion (ROM) with considerable variability between the values (Gajdosik, & Bohannon, 1987; Leighton, 1955; Leighton, 1956; Leighton, 1957; Newell & Nichols, 1965; Tucci, Hicks, Gross, Campbell, & Danoff, 1986; Youdas, Garrett, Suman, Bogard, Hallman, & Carey, 1992).

Traditionally, cervical ROM has been estimated by visual inspection during physical examination; however, this method has become obsolete since it lacks the precision and accuracy required of objective measurement. Subsequently, Moore (1949) established the goniometer as a more precise and reliable tool for measuring ROM (Low, 1976).

There may be a variety of mechanisms responsible for the stinger phenomenon, including forced cervical lateral flexion. Studies have shown that limited lateral flexion results from stingers in certain individuals (Chrisman et al., 1965). Whether lateral flexion limitation (or dysfunction) makes a football player more susceptible to the stinger injury remains to be determined.

Methods of Measurement

Reliable measurement of cervical ROM has proven to be difficult. Many methods have been conceived to obtain physical data on cervical ROM, including electrogoniometers (Alund & Larsson, 1990), gravity goniometers (Defibaugh, 1964; Leighton, 1956), protractors (Moore, 1949), and radiographs (Kottke & Mundale, 1959). Studies using goniometry have modified a variety of protractor-type devices for this purpose. Moore (1949) described a universal goniometer which consisted of a double stationary arm extending from both sides, along the 0 to 180° line of the protractor, one arm being movable and one remaining fixed. Difficulty in locating bony landmarks in the neck has prompted researchers to seldom utilize this device in cervical ROM measurement (Tucci et al., 1986).

Goniometry has proven to be a reliable method for measuring cervical ROM as the combined efforts of many vertebral segments; however, it cannot measure intersegmental motion. Radiographic analysis is necessary in order to measure specific motion between vertebral segments (Kottke & Lester, 1958). Although radiographic analysis produces accurate results, the disadvantages of radiation exposure, expense, and time are significant drawbacks to its use as a measurement tool. Because of these drawbacks, the present study utilized a goniometer, the Cervical Range of Motion® device, to measure subjects' range of motion in lateral flexion.

<u>The Cervical Range of Motion (CROM®) Inclinometer</u>

Gravity goniometers are frequently used in the clinical setting to obtain measurements for cervical flexion, extension, and lateral flexion. The Cervical Range of Motion Inclinometer (CROM®) (Performance Attainment Associates, Roseville, MN) is a commercially available type of gravity goniometer used to measure cervical range of motion (ROM). Recently, Youdas et al. (1992) utilized the CROM® to measure cervical ROM in 337 volunteers ranging from 11 to 97 years of age. Their objectives were to establish a database for normal cervical active ranges of motion (AROM), and examine intratester and intertester reliability for measuring cervical range of motion using the CROM® instrument.

To assess the accuracy of the CROM®, the researcher attached the instrument to a metal cylinder which contained a rotary table. The rotary table was rotated randomly to ten known angles. The CROM® was then used to measure each angle and values were recorded. Values obtained by the CROM® were compared to the known angle values. On the basis of small differences (range -1.5 to 0° for lateral flexion) the CROM® was determined to be an accurate tool to measure cervical lateral flexion.

A pilot study was conducted on intratester reliability in which five physical therapists each made three measurements of six active cervical movements (flexion, extension, left and right lateral flexion, and left and right rotation). To determine intertester reliability, three physical therapists each performed one measurement of six active cervical movements. Intraclass Correlation Coefficients (ICC) were used to rate intratester and intertester reliability between physical therapists when using the CROM device. No universally acceptable levels have been adopted for ICC for the purpose of describing the reliability of measurements. Youdas, Carey, & Garrett, (1991) implemented the following scale, previously reported by Myers and Blesh (1962), to grade reliability: .90-.99, high reliability; .80-.89 good reliability; .70-.79, fair reliability; .60-.69, poor reliability. The authors found that the CROM® instrument exhibited good intratester reliability for all six measurements with the exception of left rotation (ICC > .80). Particularly, for lateral flexion measurements, Youdas et al. found intratester reliability to be good (ICC = .86 right and ICC = .85 left) and intertester reliability also to be good (ICC = .87 right and ICC = .89 left).

Garrett, Youdas, & Madson (1993) also concluded that the CROM® was a reliable instrument for measuring forward head posture. The authors found reliability to be high (ICC = .93) when repeated measures were done by the same physical therapist, and reliability to be good (ICC = .83) when different physical therapists measured forward posture. The authors concluded that the CROM® exhibited good intratester and intertester reliability when measuring cervical range of motion.

On the basis of the findings of Youdas et al. (1992) and Garrett et al.

(1993), the CROM® has been shown to be a reliable and accurate device for measuring cervical ROM. In addition, the present study assessed intratester reliability of lateral flexion measurement using the CROM® instrument. The procedures used to assess reliability are included in the methods section.

Cervical Range of Motion and Stingers

Cervical range of motion measurements have been conducted in studies as part of yearly physical evaluations. Markey et al. (1993) examined cervical ROM in football players whom they had previously screened. The evaluation of players who had symptoms of stingers failed to show decreased neck or shoulder ROM. Both grip strength and radiographs were also normal on evaluation; however, asymptomatic athletes were not measured to serve as a control group for comparison. In addition, results were based on the observation of 14 subjects. In order to validate such findings, it is necessary to compare cervical ROM in symptomatic athletes with asymptomatic athletes.

Albright et al. (1985) evaluated 342 college football players who had undergone a freshman screening process to establish a history of injury. A physical examination including ROM assessment, radiographs, and strength testing was administered. In addition to muscular weakness and unusual radiographic findings, the researchers considered limited cervical ROM to be indicative of an abnormal physical examination. The authors' results demonstrated that subjects with abnormal physical examinations exhibited almost twice the likelihood of sustaining a neck injury during their football career (7% vs. 13.5%).

Albright et al. (1985) found that an abnormal physical examination, including limited cervical ROM, was a risk factor which increased the athlete's chances of having a neck injury. They concluded that evidence of abnormality on physical examination should be carefully investigated by the sports medicine staff, including the team physician and athletic trainer. The present study evaluated subjects for abnormal cervical lateral flexion and its influence on the occurrence of stingers.

Summary

The number of catastrophic injuries to the head and neck have been dramatically reduced over the past 25 years. Recognizing the mechanisms of injury and implementing legislative changes have encouraged this reduction. Noncatastrophic injuries such as stingers occur more frequently in sports than catastrophic injuries such as permanent quadriplegia. Stingers are a common injury in contact sports, particularly in collegiate football. Therefore, it was necessary to determine risk factors responsible for contributing to the occurrence of stingers in collegiate football. The literature has demonstrated that certain characteristics may increase a player's likelihood of injury: position played, level of play, neck type, and other factors contribute.

Limited lateral flexion has not been specifically studied as a risk factor which may make a football player more susceptible to a stinger injury. Cervical ROM, including flexion, extension, rotation, and lateral flexion, has been measured in symptomatic athletes after experiencing a stinger (Chrisman et al., 1965; Markey et al., 1993). Albright et al. (1985) measured cervical ROM as part of the physical examination, and identified limited range of motion as an abnormal examination. They determined that an abnormal examination increased the likelihood of future neck injuries, including catastrophic and noncatastrophic injuries (Albright et al., 1985). Chrisman et al. (1965) measured lateral flexion in players after they had experienced a stinger. No studies were found which measured lateral flexion in athletes before injury. It was necessary to examine lateral flexion ROM for its relationship to the occurrence of stingers in collegiate football.

The NCAA has established no clear guidelines with regards to return to play after stinger injury. Research suggests that many factors should be addressed in return to play decision-making including: the athlete's history of stinger injury, length of time that symptoms persist, upper extremity muscular function, and sensory perception. The present study attempted to identify lateral flexion ROM as an additional factor which should be addressed before an athlete returns to play.

Most studies reviewed were retrospective, asking the subject to recall his injury after an extended period of time. The present study attempted a more accurate incidence of stingers by analyzing data collected prospectively by Sports Medicine Staff during a single football season.

In reviewing previous studies completed on brachial plexus injuries, none were found which measured cervical ROM at the beginning of the season, then prospectively followed a team throughout the football season, documenting brachial plexus injuries as they occurred. Further no known study exists which compared cervical lateral flexion ROM between those subjects experiencing stingers and those not experiencing them during a single football season. The current study retrospectively examined data, including active lateral flexion measurements, preseason questionnaire, and injury report forms, collected during the preseason physical examination at Stanford University. The Cervical Range of Motion Inclinometer (CROM®) was tested for reliability and used for all lateral flexion ROM measurements. Lateral flexion ROM values were compared between players who experienced stingers and those who did not experience them during the 1999 football season. It was then determined if limited lateral flexion of the cervical spine was a risk factor contributing to the stinger injury.

Chapter III

METHOD

Introduction

Previous studies on stingers have established that a limitation of cervical lateral flexion may result from stinger injury (Chrisman et al., 1965); however, there was a lack of information regarding the relationship between limited lateral flexion and the subsequent occurrence of stingers. This study examined the relationship between cervical lateral flexion and the occurrence of both initial and subsequent stinger injuries in collegiate football players at Stanford University.

This study retrospectively analyzed data collected at Stanford University during the 1999 football season. The athletic training staff collected data on all football players during the Preseason Physical Examination (PPE), including cervical lateral flexion range of motion, history of injury, demographic information, and epidemiologic factors associated with the stinger injury. The staff also recorded the incidence of stingers during the 1999 football season. This study statistically analyzed the previously collected PPE and stinger data, focusing on three areas of inquiry:

1. Does limited lateral flexion motion make a collegiate football player more susceptible to a stinger injury?

2. Mechanism of stingers during the 1999 season

    a) What is the most common mechanism of injury?

    b) Do players with stingers have recurrent stingers from the same mechanism?

3. How do previous stinger injury, player position, year in school, years playing football, and cervical girth correspond with the occurrence of

stingers?

This chapter is presented in four sections: 1) characteristics of the subjects, 2) instrumentation, 3) measurement procedures used during the 1999 football PPE, and 4) statistical analysis of the data.

Subjects

All members of the 1999 Stanford University varsity football team (N = 92) were selected for the study as a convenience sample. All subjects were male and ranged from 18 to 23 years of age.

Human Subjects Review

Prior to a review of the Stanford athlete records, approval was obtained from the San Jose State University Human Subjects Institutional Review Board. The Stanford University Human Subjects committee waived its review of the research upon approval of the project by the San Jose State Institutional Review Board.

Instrumentation

This study used information gathered from three instruments during the PPE: 1) Preseason Questionnaire, 2) Cervical Range of Motion Inclinometer (CROM®), and 3) Brachial Plexus Injury Report Form. All of these instruments are used as part of the PPE and injury tracking system in the Stanford University Sports Medicine Department. Data generated from these instruments were retrospectively reviewed and analyzed.

The Preseason Questionnaire

The Preseason Questionnaire (PQ) was a self-reporting document administered to each football player during the annual PPE as part of the athlete's standard preseason health history (see Appendix A). The PQ was one of several health history sections and consisted of eight items taking one to five minutes to complete. To complete the PQ, players must rely on their recollection of past stinger injuries. This is standard for all health history reporting.

The PQ had an operational definition of a stinger clearly stated at the beginning of the questionnaire to explain the injury to the athletes. The questionnaire contained specific questions to determine players' history of stingers and identify contributing factors to the injury. Players were asked whether they had experienced a stinger in the past year, number of stingers they experienced throughout their entire football career, number of stingers they experienced in practice versus games, position(s) they currently played, and position they played at the time of injury.

The Cervical Range of Motion Inclinometer®

The Cervical Range of Motion (CROM®) Inclinometer, developed by Performance Attainment Associates, was used to measure cervical lateral flexion ROM during the annual PPE. Measurements of right and left lateral flexion were taken for each football player by a single tester. Neck girth measurements were recorded on the PPE using a standard cloth tape measure.

The CROM® instrument is used in clinical settings to measure a variety of neck motions (see Figure 4). The instrument is a commercially available gravity goniometer which combines inclinometers and magnets to measure neck range of motion accurately and reliably. The instrument positions on the head with the frame adjusting to the head like eyeglasses. Velcro® straps are used to secure the instrument to the head. The inclinometers are preset to the frame and are used to measure frontal and sagittal plane movements (right and left lateral flexion, and flexion/extension, respectively). A magnetic compass acts in conjunction with a shoulder-mounted magnetic yoke to measure motion in the transverse plane (right and left rotation).

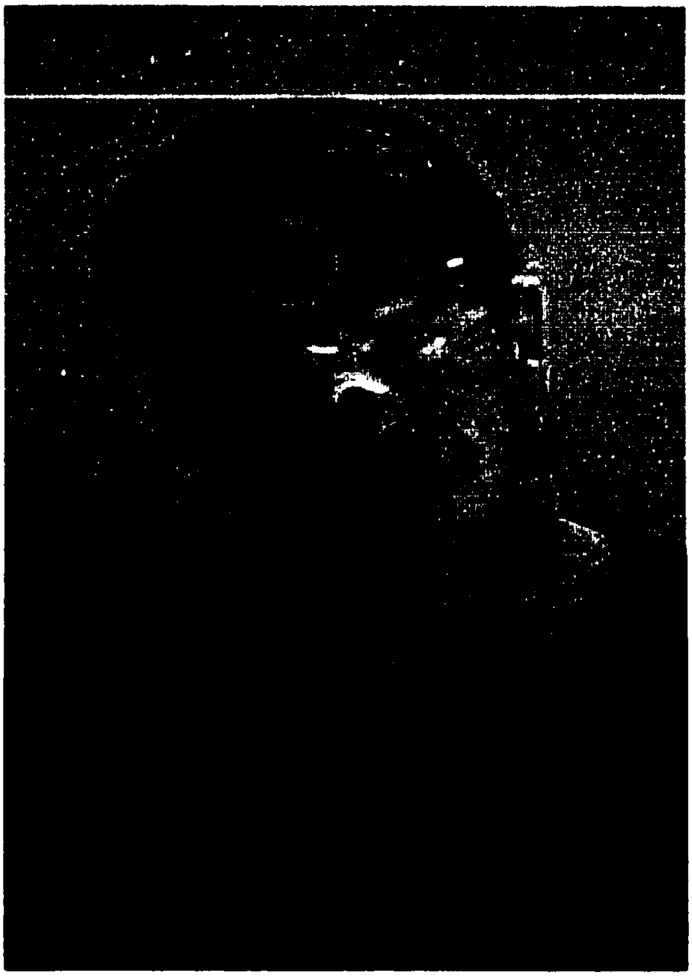


Figure 4. The Cervical Range of Motion Inclinometer®

Reliability of the Cervical Range of Motion Inclinometer®

The CROM® inclinometer and the measurement technique have previously been examined by Youdas et al. (1992) for accuracy and reliability of measurement. Youdas et al. (1992) utilized the CROM to measure cervical ROM in 337 volunteers ranging from 11 to 97 years of age. The objectives were to establish a database for normal cervical active ranges of motion (AROM), and examine intratester and intertester reliability for measuring cervical ROM using the CROM® device. Youdas et al. determined that the CROM® had good intratester and intertester reliability (Intratester ICC =.86 right and .85 left, and intertester ICC = .87 right and ICC = .89 left).

Garrett et al. (1993) also concluded that the CROM® was a reliable instrument for measuring forward head posture. Reliability was determined to be high (ICC = .93) when measured repeatedly by the same physical therapist, and good (ICC = .83) when different physical therapists measured forward posture.

The present study assessed reliability of the CROM® Instrument. Lateral flexion ROM measurements taken during the 1999 football PPE were analyzed for intratester reliability. During the PPE one Staff Athletic Trainer served as the measurement tester, performing measurements of both right and left lateral flexion for each football player on the roster. Three measurements were taken for both right and left lateral flexion; a total of six measures were taken for each athlete. Coefficient Alpha was used to measure the internal consistency (reliability) of multiple measurements. Intratester reliability using the CROM® Instrument was r = .986 (M = 44.5°, SD = 7.8°) for right lateral flexion and r = .984 (M = 43.9°, SD = 7.3°) for left lateral flexion. The scale implemented by

Youdas et al. (1991) was used to grade reliability: .90-.99, high reliability; .80-.89 good reliability; .70-.79, fair reliability; .60-.69, poor reliability. Thus, the present study found that the CROM® instrument had high intratester reliability in measuring cervical lateral flexion range of motion.

Measurement Procedures: Lateral Flexion and Cervical Girth

Active cervical lateral flexion was measured during the PPE using the CROM® instrument. Passive measurements were not assessed during the PPE since more control is required over the amount of force applied to the body segment when measuring range of motion. Thus, active measurements were considered more reliable by the athletic training staff and were chosen for use in the PPE.

Before the PPE, the tester viewed an instructional video which described and demonstrated the standardized techniques suggested by the instrument's manufacturer for mounting the CROM® and for positioning subjects for measurement. The video contained a step-by-step demonstration of measurement and recording procedures. One tester performed all cervical ROM measurements to enhance reliability. The tester practiced measuring and positioning subjects as demonstrated in the video until confident that measurements could be repeated reliably.

Cervical lateral flexion measurements were taken on August 8th and August 13th, 1999, during the annual PPE. Measurements were performed and recorded in Stanford University's Athletic Training Room. In the measurement station, subjects had a written script read to them describing the measurement procedure in detail (see Appendix B). Before cervical ROM measurements were taken, subjects performed three warm-up movements in each direction, holding each movement for a count of two. The subjects were instructed to hold their neck position at the point of soft tissue stretch but before pain or discomfort was felt. These exercises were similar to pregame and practice warm-ups and were used to increase the extensibility of cervical soft tissue, and ensured accurate ROM measurements.

After warm-ups were performed, the tester completed three active ROM measurements of both right and left lateral flexion for each player on the football roster. A total of six measures were taken for each athlete. The dial meters on the CROM® instrument were read in one degree increments, and a second athletic training staff member recorded the values on the Range of Motion Evaluation Form (see Appendix C). A measurement of Cervical girth was taken during the same measurement session using a standard fabric tape measure. The tape measure was applied evenly around the neck at the thyroid cartilage anteriorly and extended around the C4 vertebral body posteriorly. The tape measure reading was recorded in centimeters on the Range of Motion Evaluation Form (see Appendix C).

Lateral flexion measurements were taken in the sitting position. The CROM® instrument was mounted over the athlete's nose bridge and ears and secured to the head by a Velcro® strap. Each athlete sat in an aluminum frame chair so that the thoracic spine maintained contact with the chair's backrest and the lumbosacral spine filled the gap between the seat and backrest. This ensured accurate neck positioning for measurement. The athlete's feet were positioned flat on the floor, and arms rested freely at the side. Simple, standardized instructions were verbally given to each athlete by the tester (see Appendix D). Correct lateral flexion was then demonstrated to the athlete by the tester prior to measurement. The tester then instructed the athlete to sit in the chair according to the position previously described. The athlete was instructed to remove any jewelry or clothing that might obstruct cervical AROM. The tester measured right lateral flexion first, followed by left lateral flexion. This pattern was repeated three times, alternating right and left measurements. The order of measurement was held constant to ensure consistent measurement of all players.

Before each movement, the tester manually positioned the athlete's head and neck so the gravity pointer was at zero. The tester then verbally cued the athlete to "tilt your head as far as you can toward your right shoulder until you feel tightness but not pain. Please avoid lifting your left shoulder and turning your head. Please hold there for measurement." The recorder noted the end point of right lateral flexion by reading the value on the gravity pointer to the nearest degree, ensuring that the athlete did not turn his head or lift his shoulder. The athlete was then instructed to return his head to the neutral position. The tester positioned the gravity pointer at zero before taking the next measurement. The same procedure was repeated for left lateral flexion.

The tester ensured that no substitution movement occurred during measurement by placing his index finger on the athlete's chin, thereby cuing him to maintain his chin in a neutral position. The tester also placed his hand on the athlete's shoulder opposite the side of measurement to ensure that the shoulder maintained its position and did not elevate.

Brachial Plexus Injury Report Form

The Brachial Plexus Injury Report Form (BPIRF) was used by the athletic training staff as part of Stanford's injury tracking system to evaluate athletes who experienced a stinger during the 1999 football season. The staff modified an injury report form used by O'Conner et al. (1996) in their study on brachial plexus injuries and included this as part of the injury tracking standard procedures (see Appendix E). Questions 3-7, 10-12, & 14 were selected from O'Conner's form with the author's permission, and questions 8, 9, & 16 were added by the athletic training staff. An injury report form was completed for each stinger injury as it occurred during the season.

Previous studies have reported that a high percentage of football athletes may not report stingers to sports medicine personnel (O'Conner et al., 1996; Sallis et al., 1992). The Stanford athletic training staff attempted to control for unreported stinger injuries by assigning eight athletic trainers to each football practice and game. The staff was instructed to exercise an increased suspicion for detecting stinger injuries in football players. Further, during a preseason football meeting, all players were instructed to report stingers to the athletic training staff immediately. The coaching staff supported prompt stinger reporting by players to the athletic training staff.

Items on the BPIRF included: setting (practice/game), subject's position at time of injury, type of play, activity which caused injury (i.e. "blocking", or "being tackled"), mechanism of injury, whether protective equipment was used, duration of the signs and symptoms, whether the athlete returned to play, whether signs and symptoms were bilateral, and the side on which injury occurred.

Procedures

The Preseason Physical Examination (PPE)

The Stanford athletic training staff utilizes an injury tracking system to record all injuries, including stingers, sustained during each football season. As part of the annual PPE, the staff has adopted measures to examine stingers more closely and identify potential risk factors for the injuries. A Preseason Questionnaire and cervical ROM measurements are included in the standard operating procedures for the football PPE. Previous history of stinger injury and demographic information is collected as part of the Preseason Questionnaire. Athletes with previous stingers are identified and further examined. In addition, cervical ROM measurements are taken with the CROM® instrument to establish baseline range of motion data for all players before the regular football season begins.

Prior to the annual PPE required by Stanford University, subjects sign a standard Waiver and Release form (see Appendix F). By signing the waiver, each subject consents to the PPE and authorizes "an exchange of medical information concerning my health care...between authorized representatives of Stanford University...and the team physicians and/or athletic trainers." Since consent was previously granted by the subjects, direct measures were not taken to obtain consent to review medical records.

Preseason Questionnaire (PQ)

One staff athletic trainer was chosen to proctor the PQ, instructing the athletes to read the definition of injury carefully. The proctor was available to clarify a stinger injury when necessary and to answer any questions. The completed questionnaire was collected from each player and filed in the appropriate medical chart. All medical charts were filed in a locked filing cabinet in the Stanford athletic training room, accessible only to the football athletic training staff.

For the purposes of this research, each player was randomly assigned a coded identification number in lieu of his name. The codes ensured confidentiality and anonymity in the review of players' medical records. A table of random numbers was used to assign codes which corresponded with names on the football team's roster. The code sheet was kept in a locked desk drawer in the Stanford Athletic Training Room for the duration of the study, accessible only to the primary author.

Brachial Plexus Injury Report Form (BPIRF)

Football players were encouraged by the athletic training staff to report all injuries, including all stingers, as soon as possible, even if the injury seemed minor to the athlete. The staff included eight athletic trainers who attended all practices and games. This coverage allowed the staff to recognize injuries immediately when they occurred. When a stinger was reported or witnessed, a staff athletic trainer performed a brief evaluation, noting the mechanism of injury, any neuromuscular and/or sensory deficits, neck active range of motion, and any painful neck motions. The athletic trainer completed the BPIRF immediately following stinger injury. All staff athletic trainers were instructed on how to use the BPIRF as part of the injury tracking system. Identification codes were assigned on the BPIRF as on the PQ. To ensure subject confidentiality during statistical analysis, the same identification codes were assigned on the BPIRF as on the PQ.

Analysis of Data

This study statistically analyzed data collected during the 1999 football season at Stanford University. Data gathered on the football team from the PPE information and the Brachial Plexus Injury Report Form was analyzed to identify injury patterns associated with the stinger injury. Specifically, data were analyzed to determine the following:

1. The relationship of lateral flexion motion and the occurrence of
    a) initial stingers
    b) subsequent stingers
2. Mechanism of stingers
    a) most common mechanism
    b) mechanism of recurrent stingers and relationship to initial mechanism of injury
3. The influence of previous stinger injury, player position, years playing football, year in school, and cervical girth on the occurrence of stingers; the best potential predictor of stingers was identified.

Data was statistically analyzed using coded identification numbers. All statistical analyses were performed using SPSS for Windows (version 9.0; SPSS Inc. Screen images©, Chicago, IL).

Descriptive statistics were used to assess the influence of lateral flexion, history of injury, player position, year in school, and cervical girth on the occurrence of stingers during the 1999 football season. Measures of central tendency and variability, including mean and standard deviation, were used to describe subject characteristics and assess data generated by the preseason questionnaire. Descriptive statistics were also used to describe the type of equipment worn, injuries in practice versus games, type of play which caused injury, and how the player was injured (i.e. tackling, being blocked).

A Point Biserial Correlation was used to determine the relationship between lateral flexion range of motion and the occurrence of stingers. The stinger variable is a categorical measure and range of motion is a continuous measure, therefore Point Biserial Correlation was chosen. Mean range of motion was also compared between injured and uninjured players. By averaging the three lateral flexion range of motion measurements taken during the PPE, mean values for left and right lateral flexion were obtained for all subjects, both injured and uninjured. Subjects injured during the 1999 season (n = 15) had mean lateral flexion on the injured side compared with mean lateral flexion of a randomly selected side for the uninjured subjects. Each uninjured subject had the random comparison side drawn out of a hat containing both right and left choices. The side drawn was then compared to the injured subject's side injured.

Crosstabulations were calculated to determine relationships between categorical variables including stinger occurrence, history of injury, year in school, and position. Players with a history of stingers were compared to players with no history of stingers to determine the occurrence of stingers during the 1999 season in each group.

Discriminant Analysis, combining multiple regression and simple ANOVA, was used to test the hypothesis that there was a relationship between a cluster of variables (history, ROM, position, and year in school) and the occurrence of stingers during the 1999 football season. The stepwise technique was used to identify the variable which was the best potential predictor of the occurrence of stingers. Cramer's V test for practical significance was applied when significant relationships ($F > CV$) resulted from the discriminant analysis. A confidence level was set at $p < 0.05$ for determining statistically significant differences.

Summary

Research concerning the relationship between limited cervical lateral flexion and the occurrence of stingers in collegiate football is minimal. This study examined the relationship between cervical lateral flexion and the occurrence of stingers in varsity football players during a single season.

This study retrospectively examined data collected at Stanford University during the 1999 football season using PPE and injury tracking data. Statistical analysis was used to determine the relationship between range of motion and the occurrence of stingers during the 1999 football season. The most common mechanism causing stingers in the sample, and whether stingers were a precursor to recurrent stingers were determined. Demographic information generated by the PQ and BPIRF forms was used to identify injury patterns and specific risk factors associated with the stinger injury.

Chapter IV

RESULTS

Introduction

The purpose of this study was to determine the relationship between cervical lateral flexion range of motion and the occurrence of stingers. Further, this study sought to identify how previous stinger injury, player position, years playing football, year in school, and cervical girth influence the occurrence of stingers during a single football season. Data collected at Stanford University during the 1999 football Preseason Physical Examination (PPE) were analyzed. During the PPE, cervical lateral flexion was measured using the CROM® instrument, cervical girth was measured with a fabric tape measure, and a preseason questionnaire was administered which documented previous stinger injury, player position, year in school, and years playing football. A Brachial Plexus Injury Report Form was completed immediately following each stinger injury occurring during the 1999 football season.

This chapter begins with a description of the population studied followed by the applicable statistics for stingers during the 1999 season by subgroup. Lateral flexion range of motion was correlated with the occurrence of stingers during the season to determine their relationship. Also, history of injury, position, year in school, and cervical girth were compared between injured and uninjured subjects separately.

Description of Population

All 92 members from the Stanford University football team served as participants in this study; no data were missing regarding subjects. Tables 1 and 2 depict demographic data regarding subjects' age, position during the

1999 season, and injury statistics.

Fifteen players (16%) experienced stingers in 1999, while 77 players were uninjured (84%) (see Table 1). There was little difference in lateral flexion range of motion between injured and uninjured players (Injured = 42.9°± 6.2, Uninjured = 44.5° ± 7.2). The mean age of all players was 19.7 years old. Offensive Lineman comprised the highest percentage of players (20.7), and the freshman class had the highest number of players on the team (n = 27, 29.3%) (see Tables 2 & 3).

Table 1. Age and Lateral Flexion Range of Motion of Players (N = 92)

Group	n	Mean Age	SD	Range	Mean ROM Injured Side (°)	SD(°)	Range(°)
Injured	15	20.2	1.3	18-22	42.9	6.2	36-58
Uninjured	77	19.6	1.2	18-22	44.5	7.2	29-64
Combined	92	19.7	1.2	18-22	44.2	7.1	29-64

Table 2. Players by Position (N = 92)

Position	n	Percentage
offensive lineman	19	20.7
defensive lineman	16	17.4
linebacker	12	13.0
other	11	12.0
cornerback	10	10.9
safety	6	6.5
special teams	5	5.4
quarterback	4	4.3
fullback	4	4.3
Total	92	100

Table 3. Players by Year in School (N = 92)

Class	n	Percent
Freshman	27	29.3
Junior	25	27.2
Sophomore	24	26.1
Senior	16	17.4
Total	92	100

Cervical Lateral Flexion Range of Motion (ROM) and Stingers

A Point Biserial Correlation was used to examine the strength of the relationship between cervical lateral flexion ROM and stingers occurring during the 1999 season. A very weak relationship ($r_{pb} = -.08$) was found between lateral flexion ROM and the occurrence of stingers.

Mean values for cervical lateral flexion ROM were compared between players who experienced and those who did not experience a stinger during the 1999 season. Injured side ROM was compared with a randomly selected side for uninjured subjects. Mean lateral flexion ROM values for injured subjects was less than mean values for uninjured subjects (42.9°± 6.20 vs. 44.5°±7.24).

Mean lateral flexion ROM values were also compared between injured and uninjured subjects by position. Mean lateral flexion values were less for individuals who had stingers for all positions except defensive linemen (Injured = 48.9° vs. Uninjured = 45.4°) (see Table 4). These findings should be viewed with caution however, because the sample size was small when players were separated into injured and uninjured groups by position ($n > 5$), making generalizability difficult.

Table 4. <u>Lateral Flexion ROM in Injured Versus Uninjured Players by Position</u>

Position	ROM Injured (N =15)			ROM Uninjured (N = 77)		
	Mean (°)	S.D. (°)	n	Mean (°)	S.D. (°)	n
O-Line	40.5	2.3	3	45.7	8.7	16
Fullback	38.6	---	1	45.3	5.3	3
D-Line	48.9	6.6	5	45.4	7.5	11
Linebacker	38.4	2.8	4	40.4	8.0	8
Cornerback	39.3	---	1	47.2	3.4	9
Safety	46.7	---	1	48.7	8.0	5
Total	42.9	6.2	15	44.5	7.2	77

<u>Stingers During the 1999 Football Season</u>

Stingers were recorded by the Stanford University athletic training staff as they occurred during the 1999 football season. Fifteen players (16%) experienced a total of 46 stingers (range = 1-18) during the regular season. Eighty percent of the players who experienced a stinger during the 1999 season had a history of previous stinger injuries ($\underline{n}$ = 12) (see Figure 5).

The most common mechanism of stingers during the 1999 season was forced compression (neck flexed laterally or forward flexed and rotated to the same side) of the cervical spine (see Table 5). The majority of stingers (78%) were the result of the compression mechanism. This finding was dramatically influenced by one player who experienced 18 stingers, each caused by cervical compression. The remaining stingers were the result of a variety of mechanisms: forced cervical lateral flexion (16%), blunt trauma to the brachial plexus at Erb's point (3%), and other mechanisms (3%).

Five of the 15 players experiencing stingers during the 1999 season had recurrent stingers during the season, and 4 of the 5 (80%) reported a history of stingers on the Preseason Questionnaire. These players included three defensive linemen, one offensive lineman and one linebacker. After initial stinger injury, all five players experienced subsequent stingers on the same side, and 4 of the 5 players experienced subsequent stingers from the same mechanism. Four of 5 players were wearing protective equipment when the stingers occurred.

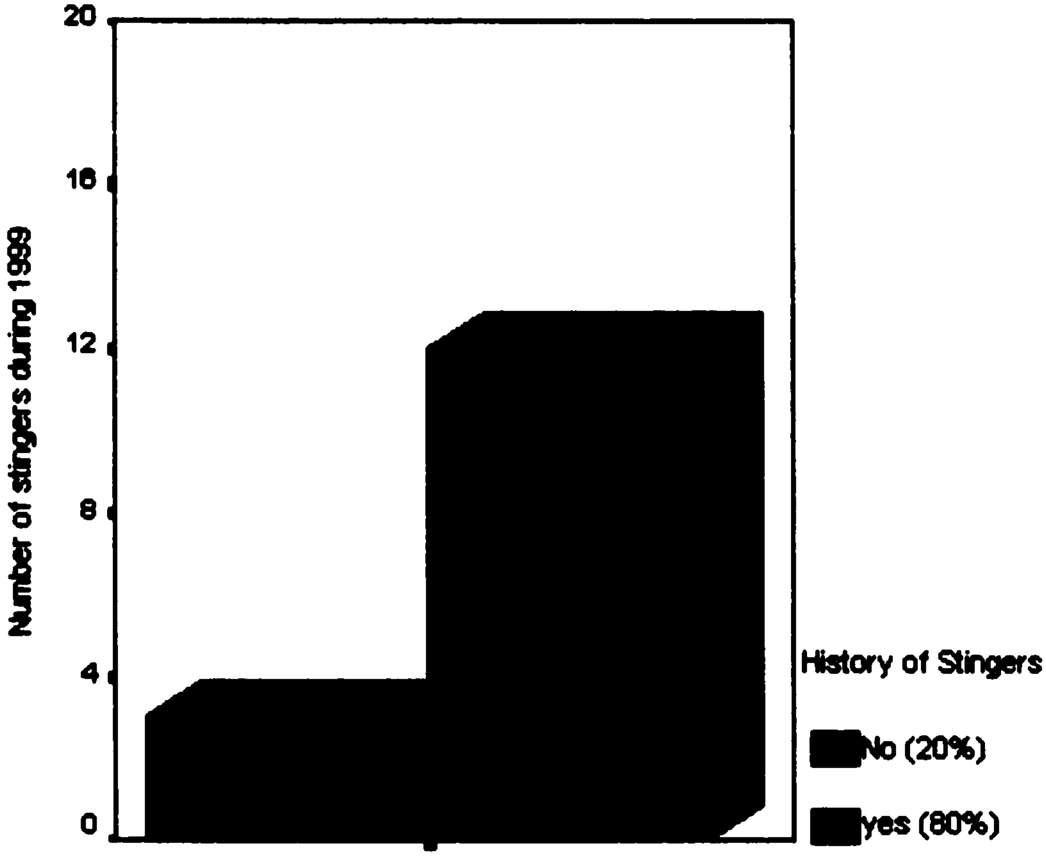


Figure 5. History of Stingers Among Players Injured During the 1999 Season (N = 15).

Table 5. Stingers During 1999 ($N = 46$)

Player	n	Mechanism	Position
1	18	Compression	Linebacker
2	8	Compression	D-Lineman
3	6	Compression (5) Traction (1)	D-Lineman
4	2	Compression	D-Lineman
5	2	Compression (1) Traction (1)	O-Lineman
6	1	Direct blow (Erb's Point)	D-Lineman
7	1	Traction	D-Lineman
8	1	Traction	D-Lineman
9	1	Traction	Cornerback
10	1	Traction	Safety
11	1	Cannot Remember	O-Lineman
12	1	Compression	O-Lineman
13	1	Compression	Linebacker
14	1	Other: Axial Load	Linebacker
15	1	Compression	Fullback

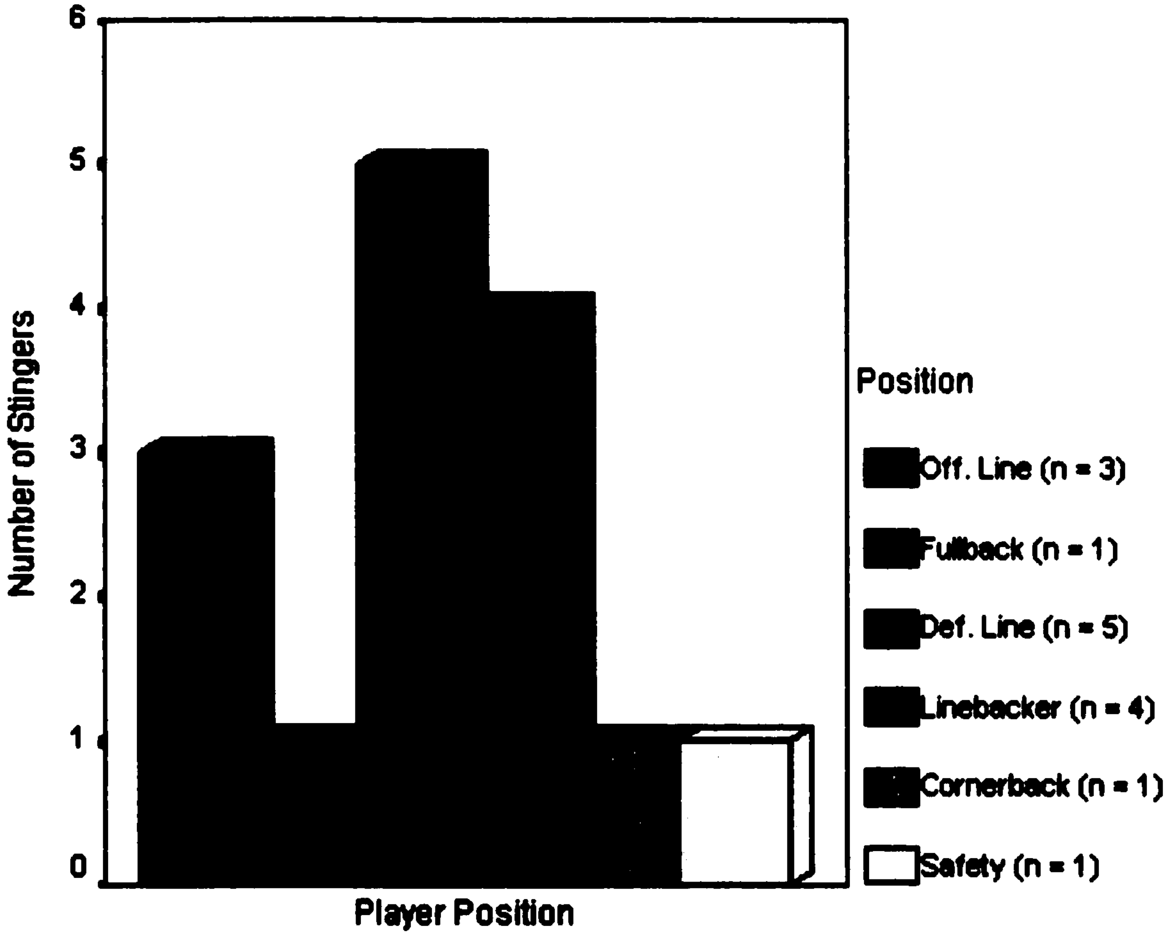
<u>The relationship of Lateral Flexion ROM, History, Position, and Year in School to the occurrence of Stingers During 1999</u>

Discriminant Analysis, which combines multiple regression and simple ANOVA, was used to determine the relationship between a cluster of variables (history, ROM, position, and year in school) and the occurrence of stingers during the 1999 football season. The stepwise technique was used to identify the variable which was the best potential predictor of the occurrence of stingers. If a variable did not contribute as a potential predictor, it was discarded from the analysis. Discriminant analysis was used to determine statistical significance of the individual relationships. When significant F values were obtained, Cramer's V was applied to assess practical significance.

History of stinger injury, when compared to the influence of the other variables in the analysis, was the best potential predictor of future stingers. After lateral flexion ROM, position, and year in school were removed, history of injury was the only variable remaining (${}_{.05}\underline{F}_{(5, 86)} = 4.11$) in the analysis. A statistically significant relationship exists between history of stingers and the occurrence of a stinger during the 1999 football season ($\underline{p} = .046 <$ alpha .05). Applying Cramer's V to test for practical significance demonstrated a weak relationship between history and stinger injury ($\underline{V} = .21$). This Cramer's V value indicates that history of injury accounted for only 4% of the variability in scores; approximately 95% of the variability in scores cannot be attributed to history. Thus, there may be many factors which explain additional variability in scores between players with stingers and those without the injury.

<u>Stingers During 1999 by Position</u>

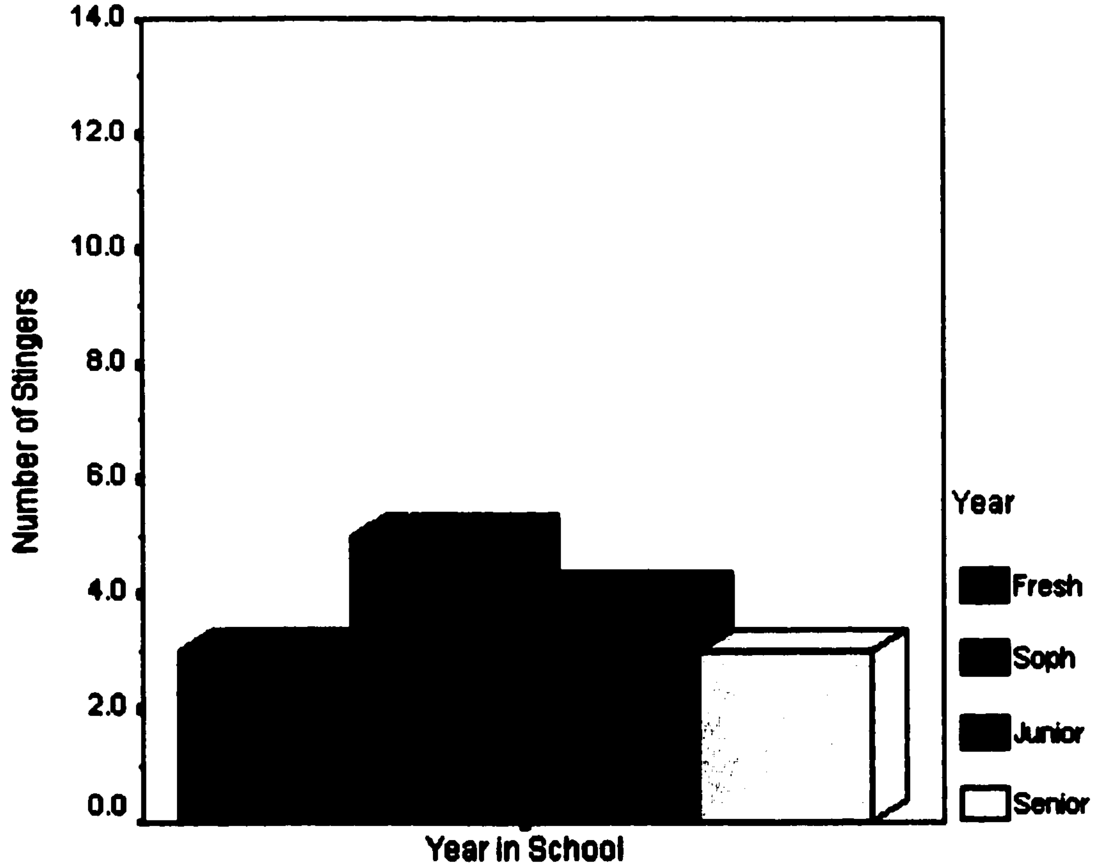
A crosstabulation of stingers by position was conducted. Defensive linemen had the highest incidence of injury (n = 5, 33%), followed by linebackers (n = 4, 27%), and offensive linemen (n = 3, 20%) (see Figure 6). Defensive players accounted for the majority of stingers (67%). One cornerback, one safety, and one fullback experienced one stinger each during the season (7% each).



<u>Figure 6.</u> Stingers During 1999 by Position (N = 15).

<u>Stingers During 1999 by Year in School</u>

Figure 7 displays results of a crosstabulation of stingers by year in school. Fifteen players had stingers during 1999. The occurrence of stingers among classes was relatively equal. Twenty percent of the players having stingers were Freshman (n = 3), 33% Sophomores (n = 5), 27% Juniors (n = 4), and 20% Seniors (n = 3).



<u>Figure 7.</u> Stingers During 1999 by Year in School (N = 15).

The majority of football players (n = 52, 57%) reported a history of stingers on the Preseason Questionnaire (see Figure 8). Crosstabulation of history by position was performed to determine if certain positions had an increased incidence of previous injury. Defensive linemen and linebackers had the most players with a history of stingers (see Figure 9): 75% of fullbacks, 69% of defensive lineman, 67% of linebackers and safeties, and 53% of offensive lineman reported a history of stingers during their football careers. Findings suggesting a large percentage of fullbacks and safeties should be interpreted with some caution since the sample size is small (n = 4 and n = 6, respectively), and may not be generalized to a larger population .

Crosstabulation of history by year in school indicates an increased history of stinger injury in upperclassmen (see Figure 10). Of the 52 players reporting a history of injury, thirty-two were upperclassmen (62%). Juniors had the highest incidence of past stinger injury (80%), followed by seniors (75%), with freshman and sophomores having the lowest incidence (19% each).

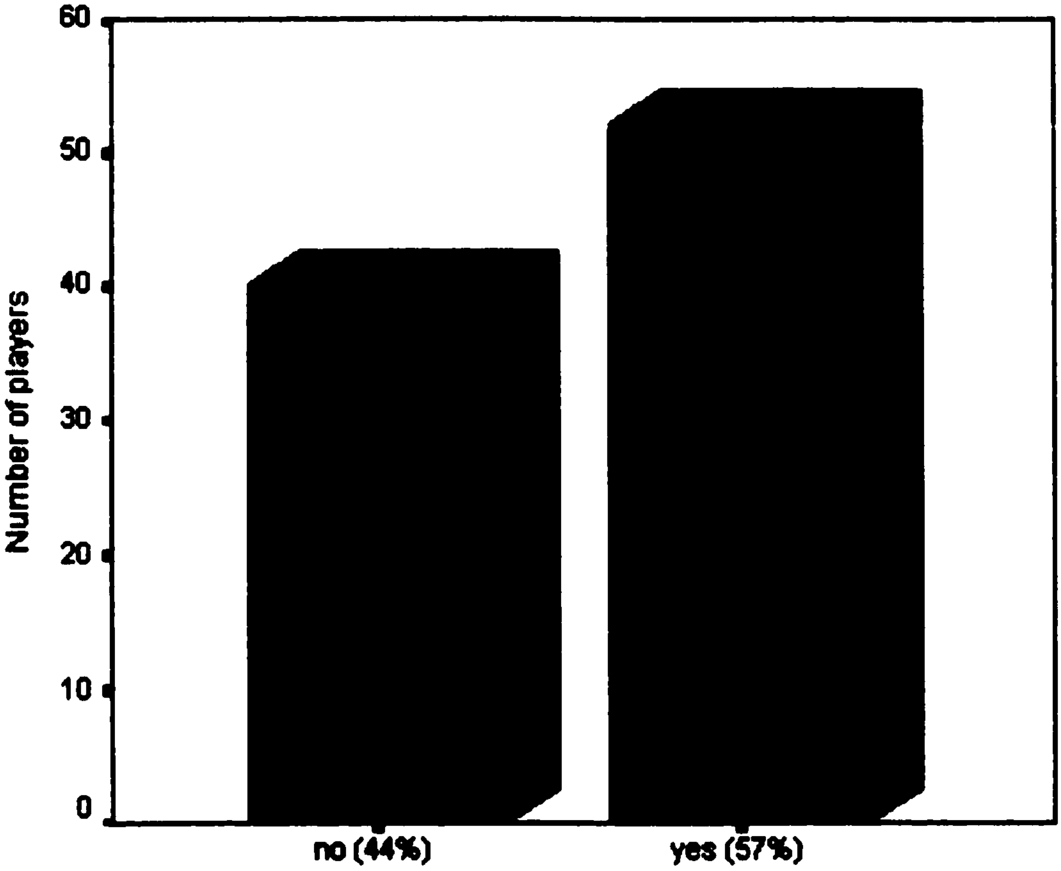


Figure 8. History of Stingers Among Players ($N = 92$).

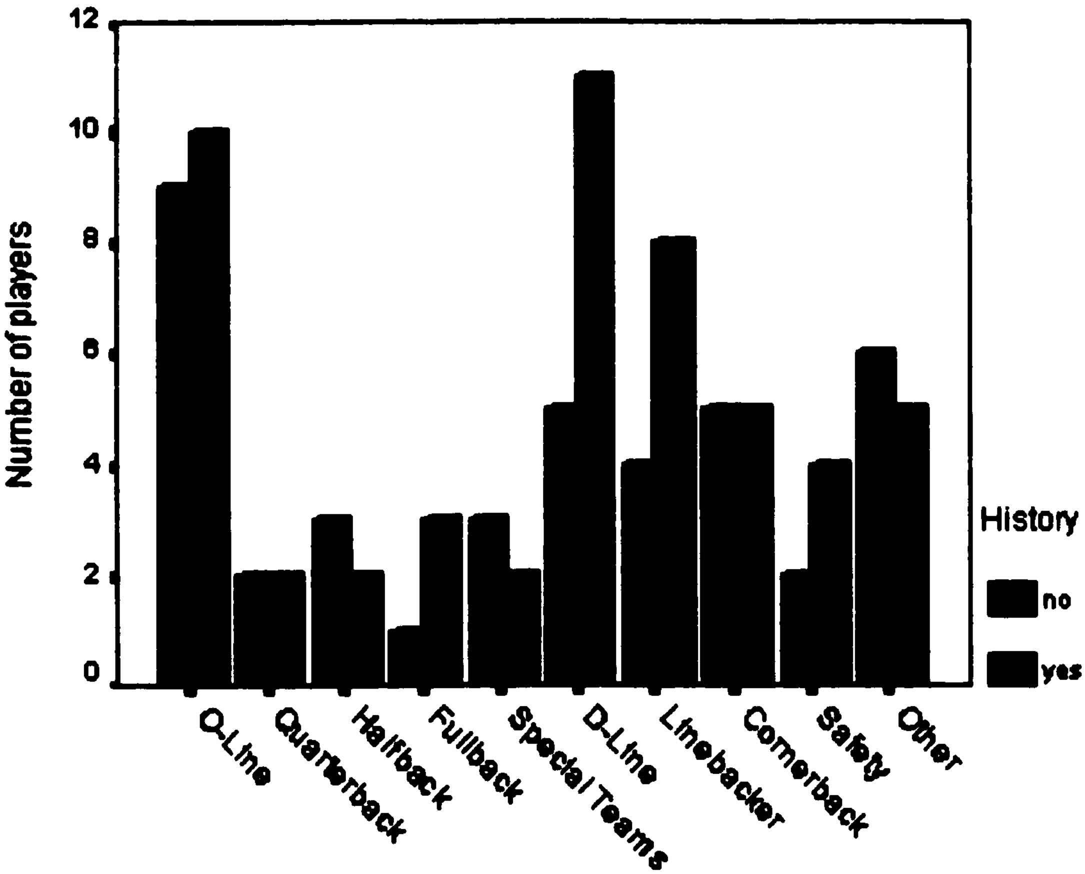


Figure 9. History of Stingers by Position (N = 92).

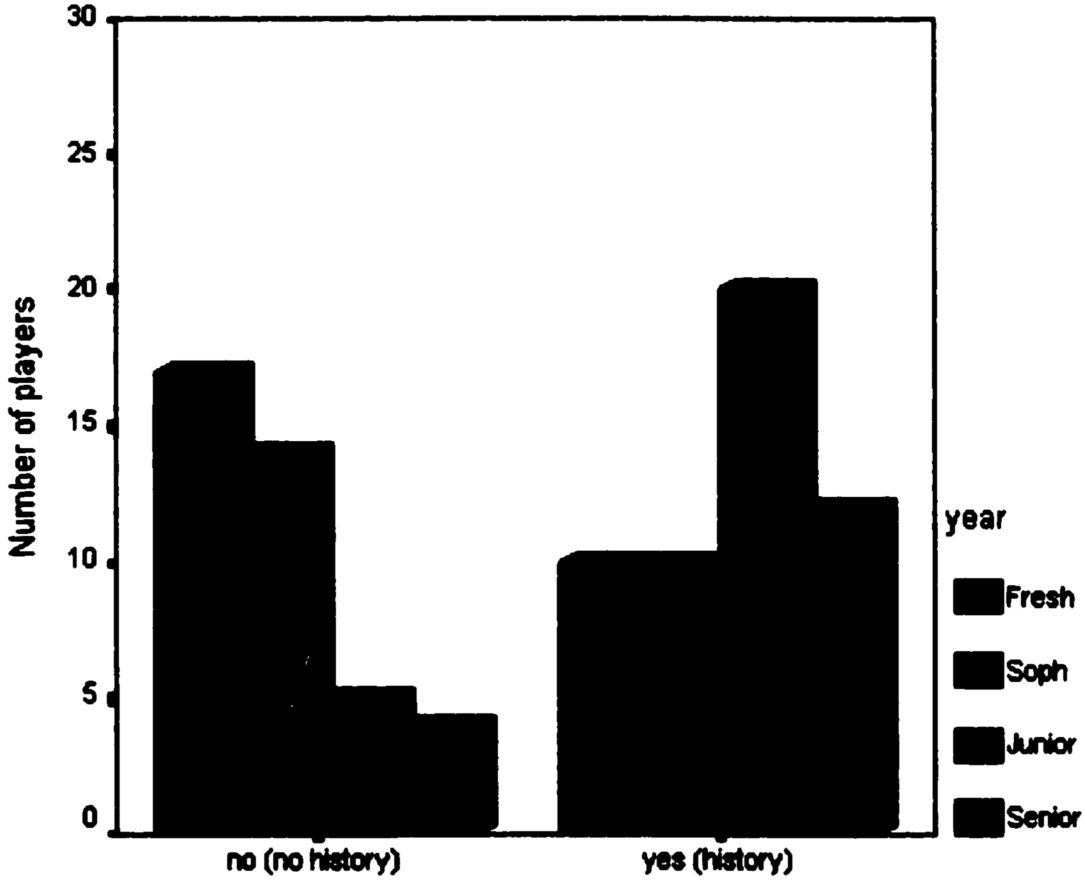


Figure 10. History of Stingers by Year in School ($\underline{N}$ = 92).

Mean ROM was compared between players with and without a history of stingers. Players with a history of stingers had higher ROM values on average than those with no previous injury (45° ± 7.19 vs. 43° ± 6.83); however, this difference in ROM values was minimal and may not represent any practical importance. This trend was opposite of that between ROM values in players injured versus those uninjured during the 1999 season.

Cervical Girth and Stingers During 1999

Descriptive statistics were used to determine the relationship between cervical girth and the incidence of stingers during the 1999 football season. A Point Biserial Correlation indicated that a substantial relationship existed between cervical girth and stingers; however, this was likely due to a large sample size ($\underline{n} = 92$), and practical significance was weak ($\underline{r}_{pb} = .22$).

Mean cervical girth values were compared between injured and uninjured subjects. Injured players had larger necks on average than those uninjured (44.10 ± 1.74 cm vs. 42.65 ± 2.49 cm) (see Table 8). This finding may be due to the player's position; linemen tend to have larger necks and also tended to have more stingers during the 1999 season.

Table 8. Cervical Girth Values for Injured and Uninjured Players

Group	N	Mean Girth (cm)	S.D.
Injured	15	44.10	1.74
Uninjured	77	42.65	2.49
Combined	92	42.88	2.44

Chapter V

DISCUSSION, CONCLUSIONS, AND RECOMMENDATIONS

Discussion

As many as 70% of collegiate football players will experience a stinger during their career; and 87% of these players may have recurrent stingers (Sallis et al., 1992). Prolonged damage and irrecoverable nerve function have been shown with repetitive severe stinger episodes, although research indicates that the risk of permanent nerve damage is small (Clancy et al., 1977; Robertson et al., 1979; & Speer & Bassett, 1990). Certain risk factors may increase a player's likelihood of having a stinger including: limited cervical range of motion, history of stingers, position played, level of play, cervical girth, year in school, and other factors. The primary focus of this study was to identify the influence of these risk factors on the occurrence of stingers during the 1999 football season.

This study investigated the relationship between cervical lateral flexion range of motion and the occurrence of stingers in collegiate football players during a single football season. Further, this study sought to identify how previous stinger injury, player position, years playing football, year in school, and cervical girth influence the occurrence of stingers. Demographic information was gathered to identify injury patterns and risk factors associated with the stinger injury.

Cervical Lateral Flexion and Stingers

A weak relationship ($\underline{r}_{pb}$ = -.08) exists between lateral flexion ROM and stingers. There was little difference in lateral flexion ROM between injured and uninjured players overall (42.9° ± 6.2 vs. 44.5° ± 7.2 respectively). Comparing

ROM by position in injured and uninjured players indicates that mean lateral flexion was decreased in all positions having stingers except defensive linemen. Currently, no evidence exists to conclude that limited lateral flexion makes players more susceptible to stingers since injured defensive linemen, who accounted for the most stingers during 1999, had larger ROM values than their uninjured counterparts. This finding may suggest that hypermobility, rather than hypomobility, increases a player's susceptibility to stingers. These findings should be viewed with caution because sample size was small when players were separated by position. In addition, the standard deviations in ROM values were large in both injured and uninjured players, indicating a high variability in lateral flexion ROM values between subjects. A high variability increases the likelihood of finding differences in ROM when there are none, or missing differences when indeed they are significant. The large standard deviations indicate a need to control for variables which may affect cervical lateral flexion ROM, and thus cause the groups to differ. History of previous stinger injury and cervical girth are two variables which may have a significant influence on lateral flexion ROM. Future studies involving stingers should address these variables individually for their influence on lateral flexion and general cervical ROM. More meaningful comparisons between ROM values for injured and uninjured football players may then be conducted.

According to Youdas et al. (1992), who established norms for cervical lateral flexion ROM among a variety of age groups, normal cervical lateral flexion for individuals aged 20-29 is 43.2°. Mean lateral flexion for all players involved in the present study was 44.2°. Using Youdas et al.'s established values as a standard, players involved in this study had normal lateral flexion ROM. Injured players ROM values (42.9°) would also be considered normal;

however, Youdas et al. measured both men and women, and did not measure athletes exclusively. Therefore, Youdas et al.'s results may not be appropriate to use with male football players. Future research should establish norms for the athletic population, and specifically for football players, separately from the general population.

Establishing norms for lateral flexion ROM in football players would give sports medicine personnel a baseline value for normal cervical lateral flexion. A clinically significant value (in degrees) for limited lateral flexion could then be determined. The established baseline could be used by team physicians when screening players during the preseason physical to determine football players with lateral flexion dysfunction. These players may then be given appropriate preventive care. Athletic trainers could treat the lateral flexion dysfunction as a preventive strategy for reducing stingers during the football season, rather than treating the athlete after the stinger has occurred.

Stingers During the 1999 Football Season

Sixteen percent of the Stanford University football team experienced stingers during the 1999 football season. Past research has indicated the possibility that stingers often go unreported (O'conner et al., 1996; Sallis et al., 1992); therefore, the incidence of stingers found in the present study may be lower than the actual number of stingers experienced during the 1999 season, since some athletes do not report stingers to medical personnel. However, the present study may demonstrate a more accurate representation of stingers than previous studies, because the occurrence of stingers was prospectively documented by the Stanford football athletic training staff (this data was retrospectively analyzed by the researcher). One study reports as many as 52% of football players experienced a stinger during a single season (Sallis et al., 1992); however, this study relied on a questionnaire which was filled out by football players and returned to the researcher, thus, it cannot be compared to stinger reporting by medical personnel. The incidence of injury in Sallis et al.'s study may be skewed since players who experienced stingers may have been more likely to return the questionnaire than those who did not. Another study gathered data from athletic trainers at high schools, junior colleges, and universities (Vereschagin et al., 1991) to determine stinger incidence. The athletic trainers reported the occurrence of stingers to researchers via an injury report form; however, practice coverage by medical personnel at the high schools may have been limited as compared with university coverage. Limited coverage may have resulted in an imprecise incidence of stingers. In the present study, eight individuals on Stanford's athletic training staff covered all practice sessions and games and thus were able to evaluate players immediately following injury. Stingers that may have otherwise gone unreported by players, or undetected by a limited staff, were able to be evaluated and documented. The comprehensive coverage of all practices and games ensured a more accurate account of stingers during the 1999 football season. In addition, the support of the coaching staff in reporting each stinger to the athletic training staff may have encouraged players to report stingers because they did not perceive that doing so would jeopardize their playing status. Thus, the incidence found in the present study may be a more accurate representation of stingers in a collegiate football team during a single season.

The actual number of stinger injuries occurring in college football remains inexact because a large scale study has not been conducted. The sample size of the present study does not allow for generalization to the larger population of collegiate football players. Perhaps the most accurate incidence of stingers might be generated by including stingers in the NCAA Injury Surveillance System (ISS). The ISS was developed to provide current and reliable data on injury trends in intercollegiate athletics (Online, www.ncaa.org/sports_sciences/injury_surveillance). Currently, the ISS does not include stingers on its forms used for tracking injuries in collegiate athletics. The ISS lists "nerve injury" as a response under type of injury; however, it does not distinguish where the nerve injury occurs (R.W. Dick, personal communication, May 16, 2000). An injury must result in one day of actual time loss in addition to the day on which the injury occurred in order to be documented in the ISS. Stingers typically do not result in any time loss due to their transient nature; therefore, this injury does not meet the requirement for reporting in the ISS System. This study recommends that stingers be made part of the NCAA Injury Surveillance System. Stingers could be tracked as an incidence of injury statistic, without the component of time loss as a prerequisite. Since injuries are tracked by individual sport, the occurrence of stingers in football specifically could be tracked. Stinger information could be made available from a greater number of institutions via the ISS. Including stingers in the ISS may lead to a a more accurate documentation of stinger incidence across NCAA football and thus, a better understanding of the stinger injury.

Past research has differed on the most frequent mechanism causing the stinger injury. More than 30 years ago, Chrisman et al. (1965) cited lateral flexion as the most common mechanism causing stingers. The study involved 17 football players with the "nerve pinch" injury, and 22 control athletes without the injury. More recent researchers have supported Chrisman et al. (1965), maintaining that stingers are frequently the result of a lateral flexion mechanism causing traction to the brachial plexus (Clancy et al., 1977; Levitz et al., 1993;

Sallis et al., 1992; Vereschagin et al., 1991). However, stingers may also result from a nerve root compression mechanism. The nerve root becomes compressed between vertebrae when the neck is forced into lateral flexion with rotation and extension toward one side, or with hyperextension. Poindexter and Johnson (1984) proposed that stingers commonly occur from a nerve root compression. Markey et al. (1993) recently cited compression, or direct trauma, to the fixed brachial plexus as another mechanism of stinger injury. Markey et al. demonstrated that compression of the brachial plexus between the shoulder pads and the superior medial scapula may cause stingers. Five players were found to have shoulder pads forced up into the Erb's point area, where the brachial plexus is most superficial.

Because stingers may result from a variety of mechanisms, as evidenced by the literature, the athletic trainer and team physician often find it difficult to prevent and treat these injuries. Preventing stingers in collegiate football is particularly difficult because players, when tackling and blocking, are subjected to extreme forces beyond their control which cause excessive cervical motion. Players who have experienced an initial stinger should have excessive cervical motion guarded by means of protective neck equipment.

The present study found that the most common mechanism causing stingers during the 1999 season was forced compression (neck flexed laterally or forward flexed and rotated to the same side) of the cervical spine (see Table 4). The majority of stingers (78%) were the result of the compression mechanism. This finding was dramatically influenced by one player who experienced 18 stingers, each caused by cervical nerve root compression due to forced extension and rotation. The majority of this player's stingers occurred during practice tackling drills. The mechanism of injury involved a component of forced hyperextension with rotation to the right side. With each subsequent stinger, less of a hyperextension/rotation force was necessary to illicit stinger symptoms. A Cowboy collar was fitted to his shoulder pads and worn during all practice sessions and games; however, he continued to experience stingers. When this subject's data was removed from the analysis, 46% (n = 12) of the remaining stingers were caused by the compression mechanism. Thus, compression was still the most common mechanism of stinger injury. These results indicate the need for protection from the mechanisms responsible for compression injury (i.e. excessive cervical lateral flexion and extension/rotation). Many varieties of protective neck equipment have been designed to limit cervical range of motion and thus protect the football player from excessive lateral flexion, extension, and/or compression leading to stingers. Protective equipment is intended to decrease neck injury and should be utilized by Sports medicine personnel to limit excessive motion in players at high risk for stingers; however, the benefits of protective equipment may not be accurate as evidenced by players in this study who had recurrent stingers while wearing protective equipment. In addition, past studies have addressed the importance of strengthening and stretching cervical musculature in order to decrease the incidence of stingers (Freeman & Clancy, 1994; Sallis et al., 1992); however, because hypomobility of the cervical vertebrae may be responsible for lateral flexion dysfunction, and may therefore be a precursor to stinger injury, restoring cervical mobility, rather than muscular strength and flexibility, may need to be the focus of treatment. An understanding of the pathomechanics involved with stingers caused by the compression mechanism will aid in the prevention of stingers.

Albright et al (1984) have explained that compression injuries of this nature occur as pathology related to previous compression sprains of the cervical facet joints. The athlete becomes more susceptible to subsequent injuries due to hemorrhage and edema surrounding the damaged ligamentous and capsular structures of the cervical vertebrae. The accumulation of edema from preceding injury may then cause narrowing of the intervertebral foramen, where the individual nerve roots exit. Thus, with foraminal narrowing, compression of the foramen (and nerve root) is more likely. This causes neurologic symptoms as the facet joints are compressed. Consequently, an extension, compression, or lateral flexion force which is significantly less than the original force causing the stinger may produce additional stingers. Sports medicine personnel must recognize the cascade of pathology and treat the football player appropriately in order to reverse the process of recurrent stingers. This usually involves increasing the mobility of cervical facet joints which have become scarred and dysfunctional, thus narrowing the foramen and compressing the exiting nerve root. Contracture of the musculature on the side injured may also need to be addressed with soft tissue mobilization and stretching of the upper trapezius and deep cervical extensors and rotators. In addition, protective neck equipment is designed, and should be used, to limit cervical range of motion and thus protect the football player from excessive lateral flexion, extension, and / or compression leading to stingers.

Five of the fifteen players experiencing stingers during the 1999 season had additional stingers during the season, and four of these players (80%) reported a history of stingers on the Preseason Questionnaire. These players included three defensive linemen, one offensive lineman and one linebacker. After initial stinger injury, all five players experienced subsequent stingers on the same side, and four of the five players experienced subsequent stingers from the same mechanism. These findings suggest that past stinger injury has a significant influence on the occurrence of future stingers. Further, recurrent stingers usually result from the same mechanism and occur on the same side. Therefore, it is imperative that the mechanism responsible for these stingers (primarily the cervical nerve pinch mechanism caused by foraminal and nerve root compression) be diminished. Sports medicine personnel need to be familiar with the mechanisms causing stinger injury so that they can effectively prevent stingers or treat the athlete after injury in order to prevent recurrent stingers.

As previously discussed, protective neck equipment, such as a Cowboy collar or neck roll, is one way way to accomplish a reduction in stingers. Past studies have indicated that protective equipment can be useful in reducing the occurrence of stingers (Markey et al., 1993 & Sallis et al., 1992); however, the findings of the present study suggest that protective equipment may not alleviate the recurrence of stingers. Four of the five players experiencing recurrent stingers during the 1999 season were wearing protective equipment when the stingers occurred. Improperly fit equipment may be an explanation for recurrent stingers. Equipment which is not secured to the shoulder pads or is ineffective in alleviating the specific mechanism responsible for causing the stinger in the particular individual may be another explanation for additional stingers. Finally, poor tackling or blocking techniques may have contributed to the recurrence of stingers in certain individuals. Sports medicine personnel must be knowledgeable on the proper use of protective equipment, must consider what motion the equipment is designed to control or limit, and must ensure that the equipment is appropriate for the particular individual if stingers are to be reduced in football. Further, the athletic trainer should ensure that coaches are correcting players when improper tackling technique is used.

History and Stingers During 1999

A limitation of the present study was that history of previous stinger injury could not be controlled. This represented a threat to the internal validity of ROM measurements. Certain subjects may have demonstrated diminished cervical lateral flexion ROM due to a previous history of stinger injury. This limitation likely affected the combined mean ROM value for players uninjured during the 1999 season. As a result, comparing injured and uninjured players did not demonstrate noticeable differences in ROM values. Controlling for history of stingers (by excluding players with a history of stingers from future studies) may give a more accurate representation of the influence of ROM on stingers.

Previous stinger injuries in football players appeared to have an influence on the occurrence of stingers during the 1999 season. The present study found that 80% of the players who had stingers during the 1999 season had previous stingers during their football career. Also, Discriminant Analysis found a statistically significant relationship between history of stingers and stingers during the 1999 football season; although practical significance was weak. The discriminant analysis established that history of injury was a stronger potential predictor of stingers during the 1999 season than were lateral flexion ROM, player position, and year in school. Although not significant, player position was the next strongest potential predictor of stinger occurrence. This suggests that a player's history of injury should be carefully examined by the athletic training staff and team physician. In addition, there are many variables excluding history that may contribute to the occurrence of stingers in collegiate football players. Player position, cervical ROM, cervical girth, and other variables may also contribute to stingers; these variables must be addressed during the preseason physical examination.

Since the preseason questionnaire is a self-reporting document which relies on the player's ability to recollect previous stingers and to accurately account for these injuries, the influence of previous history on the occurrence of stingers may be somewhat unreliable. This study sought to improve the reliability of player self-reporting by directing the majority of questions on the PQ toward stingers experienced during the previous 12 months while playing football (one question also asked if the player had experienced a stinger at any point during his football career). Players were better able to recall stingers over the past year than over an entire football career. When determining the influence of history of injury on the occurrence of stingers, it is necessary to consider that a player's recollection of injury may be a threat to the reliability that can be placed on the incidence of past injury. A longitudinal study focusing on individual players over an extended period may be justified in future studies.

Previous studies have supported that history of injury is an important factor in future injuries. Albright et al (1985) found that a history of previous neck injury was a risk factor which increased the athlete's chances of having future neck injuries, and concluded that evidence of abnormality on physical examination should be carefully investigated by medical personnel, including the team physician and athletic trainer. The present study identified that players with a history of injury were four times more likely to be injured during the 1999 season than players without a history of injury. This finding stresses the importance of implementing preventive strategies for players identified with previous stingers.

Certain risk factors for stingers, such as history of previous stingers, are under the direct control of medical personnel and should be detected early by means of a thorough preseason physical examination (PPE). PPE's are performed for all collegiate football programs; however, the present study recommends that a complete physical examination, with addresses the athlete's history of stingers, be included in the PPE. An oral history of stingers during the PPE may identify athletes at high risk for recurrent stingers and may significantly reduce the occurrence of subsequent stingers. The sports medicine staff should then initiate preventive strategies such as neck strengthening, stretching, and cervical mobilization; ensure proper tackling techniques; and issue protective equipment for those players identified at high risk for recurrent stingers.

Stingers During 1999 by Position

Defensive players have been identified as having an increased risk of injury compared with their offensive counterparts. Vereschagin et al., (1991) found that defensive players were more than two times as likely to sustain a stinger than were offensive players. Utilizing a preseason questionnaire, Marzo et al. (1991) found that linebackers and defensive backs were at greatest risk for injury. Sallis et al. (1992) also cited defensive backs for the highest occurrence of stingers (30% of the reported stingers), followed by defensive and offensive linemen (18% and 17%, respectively).

The present study's results were consistent with previous literature. Defensive linemen had the highest incidence of injury (33%), followed by linebackers (27%), and offensive linemen (20%). Defensive players accounted for the majority of stingers (67%) during the 1999 season. Defensive players may be more likely to suffer stingers due to the act of tackling. Most defensive players are taught to tackle an opponent by driving their facemask into the athlete's numbers (i.e. chest area). In order to perform this technique, the neck must rotate into slight extension; this position represents normal cervical lordosis and is considered neutral for the cervical spine (Torg et al., 1993) In the neutral position, the cervical spine is most effective in absorbing many of the extreme forces resulting from football; however, a forceful anterior to posterior blow received in the neutral position while tackling may cause the cervical spine to rotate into excessive extension. Forced hyperextension may make the player more susceptible to cervical nerve root compression, leading to stinger symptoms. Particularly, football players with previous stingers may be susceptible to recurrent stingers from this mechanism. The present study does not advise that players discontinue using this tackling technique. Indeed, the author recognizes that the cervical spine may be most protected from axial load forces in this position. Rather, while the neutral position may protect the cervical spine, this study postulates that this position may contribute to stingers caused by forced hyperextension with nerve root compression.

A pattern observed during the 1999 season was a high occurrence of stingers during special teams plays. Particularly, offensive and defensive linemen were vulnerable to stingers during these plays because of the extreme hits taken when forming and breaking the wedge (a blocking strategy designed to protect the ball carrier and create a hole for him to run through to gain yardage). This pattern may help to explain the high incidence of stingers in offensive and defensive linemen.

Cervical Girth and Stingers During 1999

Point Biserial Correlation determined that a substantial relationship existed between cervical girth and stingers; however, the relationship between the variables was weak (r_{pb} = .22). The statistical significance was likely the result of a large sample size (N = 92). Injured players had larger necks on average than those uninjured (44.1 ± 1.74 cm vs. 42.6 ± 2.49 cm). This finding is logical since most players who have large necks tend to play positions that are at increased susceptibility for stingers (i.e. defensive linemen, offensive linemen, and linebackers).

Stingers During 1999 by Year in School

The occurrence of stingers among classes during the 1999 season was relatively equal. Twenty percent of the players having stingers were Freshman, 33% Sophomores, 27% Juniors, and 20% Seniors. However, upperclassmen had a higher incidence of past stingers than did underclassmen. Of the fifty-two players reporting a history of injury on the preseason questionnaire, thirty-two were upperclassmen (62%). Juniors had the highest incidence of past stinger injury (80%), followed by seniors (75%), with freshman and sophomores having the lowest incidence (19% each). This could be due to an increased number of exposures for upperclassmen who experience more playing time in practice and games compared to underclassmen. In addition, juniors and seniors had more experience playing football at the collegiate level and were therefore had more exposures to getting a stinger. Research indicates that the incidence of stinger injury increases with an increase in level of play (Vereschagin et al., 1991). Thus, it is likely that athletes who have been competing at the collegiate level for 3 to 4 years would have a higher incidence of stingers than their freshman counterparts who have no collegiate experience. From a medical standpoint, little can be done to eliminate stinger injuries by classes; however, taking year in school, history of injury, lateral flexion ROM, cervical girth, and player position into consideration may help sports medicine personnel identify athletes susceptible to stingers while playing football.

Summary

Football players are at high risk for suffering recurrent stingers after initial stinger injury. Repetitive severe stinger injuries have the potential to result in irrecoverable nerve function. Certain risk factors may increase a player's likelihood of having a stinger including: limited cervical range of motion, history of stingers, position played, level of play, cervical girth, year in school, and other factors. The primary focus of this study was to identify the influence of these risk factors on stingers in order to implement strategies to decrease stingers in collegiate football.

Sixteen percent of the Stanford University football team experienced stingers during the 1999 football season. There was little difference in lateral flexion ROM between injured and uninjured players overall. Currently, no evidence exists to conclude that limited lateral flexion makes players more susceptible to stingers during a single football season. The most common mechanism causing stingers was forced compression and defensive players accounted for the majority of stingers during the 1999 season. No pattern was observed regarding stinger occurrence by year in school. Previous stinger injuries appeared to have a significant influence on the occurrence of stingers during the 1999 season. This suggests that a player's history of injury should be carefully examined by the athletic training staff and team physician. Injured players had larger necks on average than those uninjured. This is logical since most players who have large necks tend to play positions that are at increased susceptibility for stingers (i.e. defensive linemen, offensive linemen, and linebackers).

Currently, the NCAA Injury Surveillance System does not include stingers on its injury tracking forms. Including stingers in the ISS may lead to a a more accurate documentation of stinger incidence across NCAA football and thus, a better understanding of the stinger injury.

The role of sports medicine personnel in stinger prevention is essential. Identification of athletes susceptible to stingers can be accomplished by taking a thorough history, and considering the player's position, year in school, cervical girth, and cervical range of motion. The sports medicine staff must discern the initial mechanism responsible for stinger injury and treat the football player appropriately in order to reverse the trend of recurrent stingers. The sports medicine staff must be knowledgeable on the proper use and application of protective equipment, must consider what motion the equipment is designed to control or limit, and must ensure that the equipment is appropriate for the particular individual in reducing stingers. Further, the sports medicine staff should ensure that coaches are correcting players when improper tackling technique is being used. Perhaps most importantly, the sports medicine staff should implement treatment strategies designed to prevent recurrent stingers in players identified with previous stingers.

Conclusions

The conclusions of this investigation were:

1. The hypothesis that preseason lateral flexion ROM values would be less in players injured versus uninjured during the 1999 season was not confirmed. Lateral flexion ROM on the injured side was not a significant predictor of the occurrence of stingers during the 1999 season; however, a general pattern of limited lateral flexion ROM was observed in injured versus uninjured players when comparing them by position.

2. The most common mechanism causing stingers during the 1999

season was forced compression of the cervical spine and nerve root. Recurrent stingers usually resulted from the same mechanism and occurred on the same side. To prevent recurrent stingers, it is imperative that the mechanism responsible for initial stingers be addressed and the neck protected from excessive motion.

3. Previous stinger injuries in football players have a significant influence on the occurrence of future stingers. History of injury was a statistically significant predictor of the occurrence of stingers during the 1999 football season. Eighty percent of the players who had stingers during the 1999 season had a history of previous stingers. Lateral flexion range of motion, player position, and year in school were not statistically significant predictors of stingers during the 1999 season.

4. Defensive linemen, linebackers, and offensive linemen were the most susceptible to stingers during the 1999 football season. Defensive players accounted for the majority (67%) of stingers.

A few observations may assist future researchers in examining the stinger syndrome in football players. The results of the Discriminant Analysis used in this study indicated that no single variable could explain a significant amount of variability between players who had stingers in 1999 and players who did not, suggesting that while history of injury, lateral flexion ROM, player position, and year in school each accounted for some of the variability between injured and uninjured groups, additional variables exist which contributed to the occurrence of stingers during the 1999 season. Some of these variables, such as level of play, neck type (skinny and long, or thick and short), neck strength, on-field time, style of play, player size, player strength, and even genetic makeup, have been identified by previous authors and may have a significant influence on the occurrence of stingers. Indeed, researchers have demonstrated that some of these variables contribute to stingers; however, there is a lack of research on the extent to which each variable contributes, and which variable might be the primary contributor to stingers. The present study reveals that perhaps a number of variables each contribute to the occurrence of stingers in collegiate football players. It is likely that no variable, or no specific combination of variables, can solely account for the occurrence of stingers. Rather, the role each variable plays in contributing to stingers is dependent on the individual player. Variables may contribute in a variety of different combinations depending on the individual characteristics of a player, thus, the specific influence of each variable is extremely difficult for the researcher to isolate. This may suggest that while previous studies have implemented a multiple subject design used on an entire football team or conference, a single-subject research design may more effectively be used to isolate the variable(s) which contribute to stingers in individual football players. Particularly, players who suffer recurrent stingers could be studied individually to identify risk factors and injury patterns associated with their stinger injury. The researcher could then develop a player profile which sheds light on specific variables influencing stingers in the individual who suffers from a specific mechanism of injury.

More practically, the sports medicine practitioner could use such a profile to identify players on a particular team who exhibit similar injury patterns. The practitioner could then implement treatment strategies designed to combat risk factors associated with these injury patterns.

Recommendations

Recommendations for Future Study

The following recommendations are suggested to help improve the validity of future studies on cervical lateral flexion and stingers:

1. The study should be repeated with a greater number of subjects. An entire football conference should be recruited, and the study should be repeated in NCAA Division II, Division III, and NAIA football settings.

2. A repeated measures design should be used, with cervical lateral flexion measured during the preseason and again during the postseason. The changes in ROM values can then be determined after stingers have occurred.

3. A future study should determine the most common activity which causes stingers (i.e. tackling, blocking). The present study determined the activity responsible for each stinger during the 1999 season; however, because one player experienced 18 stingers, the majority of which were from the same activity, the data was skewed.

4. A future study should use the CROM® Inclinometer to establish cervical ROM norms for the athletic population, and specifically for football players, separately from the general population.

Recommendations for Professional Practice

The following recommendations are suggested to improve the prevention and care of stingers by Sports Medicine Personnel involved with collegiate football:

1. Certain risk factors for stingers, such as history of stinger injury, are under the direct control of medical personnel and should be detected early by means of a thorough preseason physical examination. Sports medicine

personnel should conduct a detailed physical examination, specifically addressing the athlete's history of stinger injury.

2. Rather than treatment following stinger injury, an appropriate strategy of stinger prevention is recommended which may include focusing on cervical spine mobility in addition to restoring muscular strength and flexibility. This strategy should be initiated with players who have been identified during the preseason physical examination as having a high risk for future stingers.

3. Stinger injuries should be included among injuries documented by the NCAA Injury Surveillance System. The most accurate incidence of stingers may be attained by including stingers in the NCAA ISS.

Future studies are needed to examine the influence of a variety of variables on the occurrence of stingers. Studies have been conducted on the effects of rule changes on catastrophic neck injuries; however, no study has been found which studies the effects of preventive strategies on noncatastophic neck injuries. Sports medicine personnel would benefit from a study which examines the effects of early detection of players susceptible to stingers on the occurrence of stingers during a single football season. Players identified as susceptible to stingers during preseason physical examination would begin a cervical strength and flexibility program. The effect of the prevention program could be measured by comparing the incidence of stingers during the following football season to incidences of previous seasons, or incidences generated by past studies.

A study which determines normal cervical range of motion in football players would benefit the sports medicine practitioner in detecting players with lateral flexion dysfunction. This would facilitate making an individual stinger prevention plan by knowing if and how much the player needed to increase his cervical mobility.

A study would be beneficial on the effects of neck protective equipment such as the Cowboy collar, neck rolls, and other devices, on the occurrence of stingers in football. Sports medicine personnel would benefit from a discussion of the correct technique used in attaching these devices to the player's shoulder pads in order to prevent stingers.

A study with a similar protocol would be of interest comparing cervical range of motion in players with recurrent stingers to players without stingers during a football season. A repeated measures design could be used with lateral flexion, and extension, flexion, and rotation measurements taken during preseason and postseason using the CROM® Instrument.

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Appendix A

Preseason Questionnaire

Preseason Questionnaire

Please fill out all questions and blanks to the best of your ability and recollection. Only researchers will have access to this information. All information will be confidential, so please answer honestly.

I.D.#____________ Position ___________ Age ______
Years playing football______ Dominant hand ________
Year in school_________ Year in football eligibility___________

Definition of a "Stinger" Injury: Please read carefully.

A stinger is an injury caused by a blow to the head, neck, or shoulder resulting in sudden burning pain, numbness, and/or weakness of the injured side which may extend from the neck, to the shoulder, down the arm, or into the hand. These symptoms may resolve after a short period of time (5-10 minutes), or may last for an extended period of time.

1. Have you experienced an injury as described above (a "stinger") in your football career? (including high school, and college) Please circle one:
   Yes / No

   If no, go to question #6.

   If yes, how many "stingers" have you experienced throughout your football career? Please circle one:
   a) 1-5
   b) 6-10
   c) 11-15
   d) 16-20
   e) >20

2. Have you experienced a "stinger" during the past 12 months while playing football? Please circle one:
   Yes / No

   If yes, how many "stingers" have you experienced in the past 12 months? Please cirle one:
   a) 1-5
   b) 6-10
   c) 11-15
   d) 16-20
   e) >20

3. During the past 12 months, how many stingers have you experienced while in a practice session? Please circle one.
    a) 0
    b) 1-5
    c) 6-10
    d) 11-15
    e) >15

4. During the past 12 months, how many stingers have you experienced while in a game? Please circle one.
    a) 0
    b) 1-5
    c) 6-10
    d) 11-15
    e) >15

5. What position(s) were you playing while experiencing the stinger injuries? Please circle all that apply.

a) Offensive line	f) Defensive line
b) Quarterback	g) Linebacker
c) Halfback	h) Cornerback
d) Fullback	i) Safety
e) Special Teams	j) Other:________________

6. What position do you currently play?

7. Which of the following symptoms did you experience? Please circle all that apply.

a) Numbness	c) Burning
b) Tingling	d) Pain

8. Did you report each episode of a stinger to an Athletic Trainer?
    Yes / No

APPENDIX B

Pre-participation Physical Examination Script

PRE-PARTICIPATION PHYSICAL EXAMINATION SCRIPT

1. In this station you will have measurements taken of your neck range of motion. I will be placing an instrument around your head, somewhat like eyeglasses, and asking you to bend your neck to each side, taking your ear to your shoulder. It is important that you DO NOT rotate your neck to the right or left while bending to the side, and that you DO NOT tuck or lift your chin during the movements. Also, please DO NOT lift your opposite shoulder while bending your neck to the side. This will ensure accurate measurement of your neck range of motion.
2. Please warm your neck up before I take the neck range of motion measurements. Do this by practicing the movements I just described. Practice moving to the right and the left, three times each.
3. When you are being measured, tilt your head as far as you can toward your shoulder until you feel tightness but before pain or discomfort is felt. You will need to hold the end range of motion for a few seconds while I read the instrument. Do you have any questions?
4. Please go to the next station to have your measurements taken.

Appendix C

Range of Motion / Cervical Girth Evaluation Form

RANGE OF MOTION / CERVICAL GIRTH EVALUATION

Subject I.D. # __________
Age __________
Position(s) ____________________
Number of years playing football __________
Current year of eligibility __________
Dominant side __________

*Please have patient warm-up neck by laterally flexing three times toward each side.

AROM: Cervical lateral flexion (3 measurements)

	R	L
1.	_____°	_____°
2.	_____°	_____°
3.	_____°	_____°

Girth Measurement ______________cm

Appendix D

Data Collection Script

DATA COLLECTION SCRIPT

1. Please sit straight in the chair so that your shoulder blades are against the back of the seat. Slide to the back of the chair. Put your feet flat on the floor, and rest your arms at your side.
2. I'm going to place the CROM instrument on your head now. Are you comfortable?
3. Please do not rotate your head or move your chin while performing the movements. Keep your shoulders level.
4. Please take your right ear as far as you can toward your right shoulder until you feel muscle tightness but not pain. Hold their for measurement.
5. Please take your left ear as far as you can toward your left shoulder until you feel muscle tightness but not pain. Hold their for measurement.
6. I'm going to repeat both the right and left measurements two additional times.
7. Thank you for your participation! Please let us know if you have any questions regarding the study.

Appendix E

Brachial Plexus Injury Report Form

BRACHIAL PLEXUS INJURY REPORT FORM

1. Subject Code__________ Date__________

2. Date of Injury:_____/_____/_____

3. Injury occurred during:
   a) Practice--contact
   b) Practice--noncontact
   c) Preseason scrimmage
   d) Game
   e) Other____________________

4. Position at time of injury:
   a) Offensive lineman
   b) Quarterback
   c) Halfback
   d) Fullback
   e) Special teams
   f) Defensive lineman
   g) Linebacker
   h) Cornerback
   i) Safety
   j) Other:________________

5. Injured during:
   a) Passing play
   b) Running play
   c) Kickoff / kickoff return
   d) PAT / FG
   e) Punt return
   f) Blocking sled / tackling bag
   g) Practice drill. (Drill name:________________)
   h) Can't remember
   i) Other

6. Injury activity:
   a) Tackling
   b) Being tackled
   c) Blocking
   d) Being blocked
   e) Throwing
   f) Punting / kicking
   g) Catching / pass defense
   h) Can't remember
   i) Other:________________

7. Mechanism of Injury:
   a) Traction - shoulder depression with forced lateral flexion to the opposite side
   b) Compression - neck flexed laterally or forward flexed and rotated to same side
   c) Direct blow to supraclavicular area or shoulder
   d) Cannot remember
   e) Other:____

Brachial Plexus Injury Report Form (Cont.)

8. Was protective equipment being used at time of injury? Circle one:
   a) Yes b) No

9. Duration of injury:
   a) < 5 min.
   b) 5-15min.
   c) 15-60 min.
   d) < 24 hrs.
   e) > 24 hrs.
   f) unknown

10. Physical exam revealed: (Circle all that apply)
    a) No pain
    b) Pain with extension
    c) Pain with lateral flexion
    d) Pain with forward flexion
    f) Pain with rotation
    g) Pain with Spurling's maneuver
    h) Bony tenderness
    i) Pain with compression of neck

11. Motor exam revealed weakness of: (Circle all that apply)
    a) No weakness
    b) Trapezius
    c) Supraspinatus
    d) Infraspinatus
    e) Deltoid
    f) Biceps
    g) Triceps
    h) Pronators
    i) Supinators
    j) Wrist extensors
    k) Wrist flexors
    l) Grip

12. Sensory deficits: (Circle all that apply)
    a) None
    b) C5
    c) C6
    d) C7
    e) C8
    f) T1

13. Did athlete return to play:
    a) With protective neck equipment
    b) Without protective neck equipment
    c) Athlete did not return to play

14. Were signs / symptoms bilateral?
    a) Yes b) No

15. Which side did injury occur on?
    a) Right b) Left

Appendix F

Waiver and Release Form

WAIVER AND RELEASE FORM

THE UNDERSIGNED, HEREWITH:

A. Understands he/she must refrain from practice or play during medical treatment until he/she is discharged from treatment or given a written permit by the attending physician to resume participation.

B. Certifies the answers to the questions on the Health History survey are correct and true.

C. Understands his/her having passed the physical examination does not necessarily mean he/she is physically qualified to engage in athletics, but only that the examiner did not find any medical reason to disqualify him/her.

D. Fully realizes Stanford University Athletic Department cannot be held responsible for any previous medical condition(s) he/she might have.

______________________________ Student-Athlete Signature   ________________ Date

WAIVER AND RELEASE

The undersigned requests that he/she be allowed to participate as a/an __________ player. In consideration of being afforded such opportunity, the undersigned hereby assumes the risk of injury inherent in such activity, and waives any claim for damages and/or financial responsibility against Stanford University, the Stanford University Department of Athletics, the Sports Orthopedic and Rehabilitation Medicine Associates, the Physiatry Medical Group, Stanford University Medical Clinic, Cowell Student Health Center, and the Stanford University team physicians and/or athletic trainers.

I understand that this form is part of my education records under the Family Education Rights and Privacy Act of 1974 and may not be disclosed without my consent. I consent to an exchange of medical information concerning my health care, including this evaluation form, between authorized representatives of Stanford University, the Stanford University Department of Athletics, Sports Orthopedic and Rehabilitation Medicine Associates, the Physiatry Medical Group, Stanford University Medical Clinic, Cowell Student Health Center, and the Stanford University team physicians and/or athletic trainers.

______________________________ Student-Athlete Signature   ________________ Date

PLAYER AUTHORIZATION

I acknowledge that all future injuries and/or illnesses must be reported to the Team Physician and Athletic Trainer, no matter how minor it may seem. I authorize the team physicians, athletic trainers, and any other designated medical staff to examine and treat any injuries which may occur while playing for Stanford University. I authorize the team physicians, athletic trainers, and any other designated medical staff to communicate their findings and recommendations to the team coach and Stanford University officials.

______________________________ Student-Athlete Signature   ________________ Date